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Re: Application of Masao IKEGUCHI
METHOD OF CONTROLLING AN ELECTRONIC CAM TYPE ROTARY CUTTER, AND METHOD OF PRODUCING AN ELECTRONIC CAM CURVE
Assignee: KABUSHIKI KAISHA YASKAWA DENKI
Our Ref: Q65291

Dear Sir:

The following documents and fees are submitted herewith in connection with the above application for the purpose of entering the National stage under 35 U.S.C. § 371 and in accordance with Chapter II of the Patent Cooperation Treaty:

- ☑ an executed Declaration and Power of Attorney.
- ☑ an English translation of the International Application .
- ☑ twenty-four (24) sheets of drawings.
- ☑ an English translation of Article 34 amendments (annexes to the IPER).
- ☑ an executed Assignment and PTO 1595 form.
- ☑ International Search Report, a Form PTO-1449 listing the ISR references, and a complete copy of each reference.

It is assumed that copies of the International Application, the International Search Report, the International Preliminary Examination Report, and any Articles 19 and 34 amendments as required by § 371(c) will be supplied directly by the International Bureau, but if further copies are needed, the undersigned can easily provide them upon request.

The Government filing fee is calculated as follows:

Total claims	6	-	20	=		x	$18.00	=	$.00
Independent claims	3	-	3	=		x	$80.00	=	$.00
Base Fee									$860.00
Multiple Dependent Claim Fee									$270.00
TOTAL FILING FEE									$1130.00

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Recordation of Assignment	$ 40.00
TOTAL FEE	$1170.00

Checks for the statutory filing fee of $1130.00 and Assignment recordation fee of $40.00 are attached. You are also directed and authorized to charge or credit any difference or overpayment to Deposit Account No. 19-4880. The Commissioner is hereby authorized to charge any fees under 37 C.F.R. §§ 1.16, 1.17 and 1.492 which may be required during the entire pendency of the application to Deposit Account No. 19-4880. A duplicate copy of this transmittal letter is attached.

Priority is claimed from January 11, 1999 based on Japanese Patent Application No. 11-4523.

Respectfully submitted,

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Description

Method of Controlling an Electronic Cam type Rotary Cutter, and Method of Producing an Electronic Cam Curve

Technical Field

The present invention relates to a method of controlling a machine in which a motion of a specific portion in one cycle is defined, such as a rotary cutter for continuously cutting web paper, an iron sheet, or the like that successively travels, into a preset length and without stopping the travel, or a continuous packaging machine for performing a sealing work in synchronization with a film, paper, or the like that successively travels, by using a servo motor and producing an electronic cam curve including a prediction to the next cycle.

Background Art

As a cutting control method for a rotary cutter of the conventional art, for example, known is a motion controller which is disclosed in JP-A-5-337729. Fig. 20 is a control block diagram of the motion controller of the conventional art. The speed and travel distance of a travelling workpiece 215 are converted at an arbitrary ratio by an electronic gear 203, and a pulse distributor (1) 204 produces a command pulse. The cut length of the workpiece is input through a setting device 205, a position correction amount of a rotary blade is obtained by a command data calculating section 206, a correction pulse is output from a pulse distributor (2) 208, and the pulses are combined with each other by a

combining circuit 209, thereby performing a servo control.

Specifically, in the case where, as shown in a speed pattern diagram of Fig. 21, the travelling speed of the workpiece 215 is set to V1 as shown in Fig. 21A and the peripheral speed of the rotary blade 213 is adjusted by the distributor (1) so as to be equal to the workpiece traveling speed V1 as shown in Fig. 21B, the speed is corrected by a speed waveform V2 due to a position correction command for the rotary blade (by an output of the distributor 2) as shown in Fig. 21C because the cut length of the workpiece 215 does not coincide with the peripheral length of the rotary blade, and, as shown in Fig. 21D, a cutting zone is controlled to the same speed as the line speed of the workpiece 215 and a noncutting zone (correcting zone) is additionally controlled to a speed V3 = V2 + V1.

Furthermore, Figs. 21E and 21F show a correcting direction in the case of, for example, a long cutting operation in which the cut length is larger than the peripheral length of the blade, and a subtractive control is performed in the deceleration direction. In addition to the rotary cutter, also a lateral sealing mechanism of a vertical continuous packaging machine, or the like can be control driven.

Fig. 22 is a view showing an example of an electronic cam control of the conventional art, and is a control block diagram of an electronic cam which is disclosed in JP-A-7-311609. In the configuration of Fig. 22, a cam curve 319 which is previously prepared in accordance with operation characteristics of a load 313 is input into a CPU 301 of calculating means, and the CPU 301 outputs a position command value (S), a speed command value (V), and an acceleration command value (A) to comparators in which a subtractor is

combined with a counter, a V/F converter, or a differentiator, respectively, and performs an F.B. control on the basis of an output pulse of a PG 314 which detects a displacement of the load 313.

In the conventional art examples, in the case of JP-A-5-337729, however, the correction method in which the cut timing is adjusted by adding (in a short cutting operation) or subtracting (in a long cutting operation) a trapezoidal speed corresponding to the difference between the peripheral length and the cut length, to or from the peripheral speed of the rotary blade that is equal to the line speed V1 of the working line is not novel. In contents of the control also, with respect to the position control, an optimum position pattern is not produced by an electronic cam curve or the like. Therefore, the speed control is performed mainly on the basis of the addition or the subtraction of the corrected speed.

In such a trapezoidal speed control, as shown in Fig. 24, particularly in a control of a rotary cutter, the line speed must be reduced in a short cutting operation because the peak of a torque required during acceleration or deceleration is high. This produces a problem in that the productivity is lowered.

In the case of the proposal of JP-A-7-311609, the technique of reducing the follow-up delay as far as possible by means of a control on the basis of the cam curve 319 (position pattern) which is previously prepared is proposed, and the configuration other than that for using the cam curve is strictly identical with the line configuration of the conventional art. Namely, the configuration of Fig. 22 is a line configuration in which a speed feedforward (V) and a torque compensator (A) by the CPU are added to a position control

shown in Fig. 23 and using a conventional servo motor, and is within a range of a conventional control technique. When the speed command (V) and the acceleration command (A) are to be produced by the CPU based on the position pattern only, a differential process must be performed on the basis of the scan period. The speed command (V) and the acceleration command (A) which are produced in this way already lag behind the actual speed. Therefore, the effect is reduced to one half its original one unless a countermeasure from the viewpoint of the predictive control is taken.

As described above, a system of the conventional art has a problem in that the traceability is so poor that the control accuracy is low.

It is an object of the invention to provide a method of controlling an electronic cam type rotary cutter, and a method of producing an electronic cam curve which, in a control of, for example, a rotary cutter or a continuous packaging machine which is driven by a servo motor, perform a correct position control while a position loop is formed in the whole region and an electronic cam control of a continuous correlation system extending to the next cycle is configured, enable a control due to the same algorithm that can automatically cope with both long and short cut lengths or bag lengths, remarkably improve the productivity in a short cutting operation, have an excellent traceability, and improve the control accuracy.

Disclosure of Invention

In order to attain the object, the invention is characterized in that, in a method of controlling an electronic cam type rotary cutter which is driven by a servo motor, and which is controlled in long and short cutting operations

by different speed waveforms on the basis of an electronic cam curve, a position loop is formed in a whole region on the basis of an electronic cam curve, an electronic cam curve of a cubic function is used as a position pattern for a noncutting zone, and an electronic cam curve of a quadratic function is used as a speed pattern, whereby a control is enabled with causing a same algorithm to automatically cope with the long and short cutting operations and a change of a line speed.

According to this configuration, a correct position pattern which is to be controlled is previously prepared, and a position control is performed at every moment over the whole region including the cutting and noncutting zones on the basis of the position pattern, thereby enabling a correct cutting position control on the basis of an electronic cam curve. As the electronic cam curve, a cubic function is used for a position pattern, and a quadratic function is used for a speed pattern. By the control contents based on an algorithm in which continuous correlations between the position and the speed at the timing when the cutting operation is ended, and those at the timing when the cutting operation of the next cycle is started are maintained, a cutting position control can be configured which has an excellent traceability, and in which the same algorithm is enabled to automatically cope with the long and short cutting operations and a change of a line speed.

The invention is characterized in that, in a method of controlling an electronic cam type rotary cutter which is controlled in long and short cutting operations by different speed waveforms on the basis of an electronic cam curve, and in which a line speed is controlled to be reduced in the short cutting operation, a position loop is formed in a whole region on the basis of

an electronic cam curve, an electronic cam curve of a cubic function is used as a position pattern for a noncutting zone, and an electronic cam curve of a quadratic function is used as a speed pattern, whereby necessity of reduction of the line speed is eliminated even in a length range which is shorter than a range of a conventional art, and a cutting operation is enabled while maintaining the line speed to 100%.

According to this configuration, the speed pattern based on the electronic cam curve is a quadratic curve, and a torque required for acceleration and deceleration in the noncutting zone is dispersed over the whole of the region, so that the root mean square of the torque is smaller than that in the case of a trapezoidal speed where the acceleration or deceleration time is somewhat short. In a short cutting operation where the acceleration or deceleration frequency is higher, particularly, the cutting is enabled even when the line speed is not lowered to a length which is shorter than that of a conventional art.

In the method of controlling an electronic cam type rotary cutter, preferably, a speed pattern of a spiral blade due to a cam curve diagram is, in a cutting zone, identical with the line speed, and, in the noncutting zone, a quadratic curve which is raised in the short cutting operation, and a quadratic curve which is reduced in the long cutting operation, and a speed pattern of a straight blade is a pattern which is different from the spiral blade in that only the speed in the cutting zone is proportional to $1/\cos\theta$.

According to this configuration, both the spiral blade and the straight blade can be similarly controlled by a speed pattern of a quadratic curve. In the case of a straight blade, the speed pattern in the cutting zone is set to be

$1/\cos\theta$, thereby allowing a workpiece which continuously travels at the line speed, to be cut in a direction perpendicularly to the traveling direction in the same manner as the case of a spiral blade.

The invention is characterized in that, after a sealing work, a cutting work, or the like is performed in synchronization with a workpiece in a specific phase zone of one cycle of a rotary mechanism such as a lateral sealing mechanism of a vertical continuous packaging machine which is driven by a servo motor, or a rotary cutter which cuts a workpiece into a constant length, a cubic function is used in a position command according to a continuous correlation control system including a prediction to a start of a work in a next cycle, and a quadratic function is used in a speed feedforward, whereby an optimum electronic cam curve is obtained while allowing a bag length or a cut length of the workpiece to automatically perform correspondence irrespective of a value of peripheral length/M (M = 1, 2, ..., the number of sealing faces or blades).

According to this configuration, when a sealing or cutting work is to be performed in synchronization with the line speed of a film, paper, or another workpiece in a specific phase zone (a sealing zone or a cutting zone) in one cycle of the rotary mechanism, a position pattern is used as a position command, and a speed pattern is used as a speed feedforward by a continuous correlation control in which a cubic function is used as a cam curve (the position pattern) satisfying four boundary conditions of the final position and speed in the specific phase zone, and the initial position and speed in a specific phase zone of the next cycle, and a quadratic function that is its differential value is used as the speed pattern, and which includes a predictive control for

the next cycle, and an electronic cam control in which the position and speed are again made coincident with the line speed at a initial time in the specific phase zone of the next cycle can be realized.

In the method of producing an electronic cam curve, preferably, a rotational speed n_2 and a rotational position y_2 of the lateral sealing mechanism or the cutting blade in the sealing zone or the cutting zone are

$$n_2 = N_1 \quad \text{(rpm)}$$

$$y_2 = (1/M - Y_1)/(Tc - t_3) \times (t - Tc) + 1/M \quad \text{(rev)}$$

where N_1 is the line speed at a start point, Y_1 is a rotational position of a cutting start point, t_3 is a time of the cutting start point, and Tc is one cycle time,

a curve equation of the nonsealing zone or the noncutting zone is a cubic function having four coefficients satisfying four boundary conditions of velocities V_1 and V_2 and positions X_1 and X_2 at times T_1 and T_2, a position x and a speed v which is obtained by differentiating the position x are indicated by

$$x = At^3 + Bt^2 + Ct + D \quad \text{(rev)}$$

$$v = 3At^2 + 2Bt + C \quad \text{(rps)},$$

(T_1, X_1) and (T_2, X_2) are substituted into equation x, (T_1, V_1) and (T_2, V_2) are substituted into equation v, the equations are solved for A, B, C, and D, $T_1 = 0$, $T_2 = t_3$, $X_1 = 0$, $X_2 = Y_1$, $V_1 = N_1/60$, and $V_2 = N_1/60$ are substituted to obtain A, B, C, and D, and cam curve equations at a rotational speed $= n_1$ and a rotational position $= y_1$ in the nonsealing zone or the cutting zone, and the rotational speed n_2 and the rotational position y_2 in the sealing zone or the noncutting zone are obtained as

$n_1 = 60(3At^2 + 2Bt + C)$ (rpm)

$n_2 = N_1$ (rpm)

$y_1 = At^3 + Bt^2 + Ct + D$ (rev)

$y_2 = (1/M - Y_1)/(Tc - t_3) \times (t - Tc) + 1/M$ (rev).

According to this configuration, when the coefficients of the four boundary conditions, (T_1, X_1) and (T_2, X_2), and (T_1, V_1) and (T_2, V_2) are substituted into the cubic function having four coefficients

position $x = At^3 + Bt^2 + Ct + D$, and

its differential equation or speed $v = 3At^2 + 2Bt + C$,

and the equations are solved for A, B, C, and D, the followings are obtained:

$A = \{2(X_1 - X_2) - (T_1 - T_2)(V_1 + V_2)\}/K$

$B = [(V_1 - V_2)(T_1 - T_2)(T1 + 2T_2) - 3(T_1 + T_2) \times \{X_1 - X_2 - V_2(T_1 - T_2)\}]/K$

$C = \{6(X_1 - X_2)T_1 \bullet T_2 + 3(T_1 + T_2)(V_1 \bullet T_2^2 - V_2 \bullet T_1^2) + 2(T_1^2 + T_1 \bullet T_2 + T_2^2)(V_2 \bullet T_1 - V_1 \bullet T_2)\}/K$

$D = -[(X_1 - V_1 \bullet T_1)T_2^2(3T_1 - T_2) + (X_2 - V_2 \bullet T_2)T_1^2(T_1 - 3T_2) + 2(V_1 - V_2)T_1^2 \bullet T_2^2]/K$

$K = -(T_1 - T_2)^3$.

When $T_1 \to 0$ (the final time of the cutting or sealing zone), $T_2 \to t_3$ (the initial time of the cutting zone of the next cycle), $X_1 \to 0$ (the position at time T_1), $X_2 \to Y_1$ (the position at time $T_2 = t_3$), $V_1 \to N_1/60$ (the speed at time $T_1 = 0$), and $V_2 \to N_1/60$ (the speed at time t_3) are substituted into thus obtained A, B, C, and D to obtain A, B, C, and D, it is possible to obtain a cam curve equations,

$n_1 = 60(3At^2 + 2Bt + C)$

$n_2 = N_1$

$y_1 = At^3 + Bt^2 + Ct + D$

$$y_2 = (1/M - Y_1)/(Tc - t_3) \times (t - Tc) + 1/M.$$

Brief Description of Drawings

Fig. 1 is a control block diagram of an electronic cam type rotary cutter which is a first embodiment of the invention.

Fig. 2 is a conceptual diagram of the rotary cutter shown in Fig. 1.

Figs. 3A and 3B are views showing kinds of rotary cutter blades shown in Fig. 2.

Figs. 4A to 4D are views showing the structures of the rotary cutter blades shown in Fig. 2.

Fig. 5 is a view showing positional relationships between the rotary cutter blades shown in Fig. 2 and a workpiece.

Figs. 6A and 6B are views showing a cum curve graph of a spiral blade of the rotary cutter shown in Fig. 1. (Hereinafter, the figures are often generally referred to as Fig. 6.)

Fig. 7A and 7B are views illustrating a function constituting the cam curve shown in Fig. 6.

Fig. 8 is a view showing a cam curve equation of the cam curve shown in Fig. 6.

Figs. 9A and 9B are views showing a cum curve graph in the case where the cutter shown in Fig. 1 is a straight blade. (Hereinafter, the figures are often generally referred to as Fig. 9.)

Fig. 10 is a view showing a cam curve equation of the cam curve shown in Fig. 9.

Figs. 11A and 11B are views showing relationships between the speed

pattern shown in Fig. 6 and a torque. (Hereinafter, the figures are often generally referred to as Fig. 11.)

Figs. 12A and 12B are views comparing a quadratic functional speed pattern shown in Fig. 6 with a trapezoidal speed pattern in the conventional art. (Hereinafter, the figures are often generally referred to as Fig. 12.)

Figs. 13A and 13B are generalized views of the trapezoidal speed pattern shown in Fig. 12. (Hereinafter, the figures are often generally referred to as Fig. 13.)

Fig. 14 is a view showing an LV curve of the rotary cutter shown Fig. 1.

Fig. 15 is a control block diagram of a lateral sealing mechanism of a vertical continuous packaging machine which is a second embodiment of the invention.

Fig. 16A and 16B are views schematically showing the structure of the lateral sealing mechanism shown in Fig. 15. (Hereinafter, the figures are often generally referred to as Fig. 16.)

Fig. 17 is a view showing positional relationships in the double-heater lateral sealing mechanism shown in Fig. 16.

Figs. 18A and 18B are views showing a cum curve graph of the lateral sealing mechanism shown in Fig. 15. (Hereinafter, the figures are often generally referred to as Fig. 18.)

Fig. 19 is a view showing a cam curve equation of the cam curve shown in Fig. 18.

Fig. 20 is a control block diagram of a motion controller of the conventional art.

Figs. 21A to 21F are speed pattern diagrams of the controller shown in Fig. 20.

Fig. 22 is a block diagram of an electronic cam control in a conventional art.

Fig. 23 is a control block diagram of a servo motor of the conventional art.

Figs. 24A and 24B are views showing a trapezoidal wave speed pattern of the conventional art and a torque. (Hereinafter, the figures are often generally referred to as Fig. 24.)

Best Mode for Carrying Out the Invention

Hereinafter, a first embodiment of the invention will be described with reference to the figures.

Figs. 1 to 14 are views showing the first embodiment of the invention.

Referring to Fig. 1, 1 denotes a digital controller which performs a constant scan control, 2 denotes a servo driver which drives a servo motor 3, 4 denotes a pulse generator for the motor 3, 11 denotes a rotary cutter which cuts paper, a iron sheet, or the like into a constant length, 12 denotes a measuring roll which detects the travel distance of a workpiece, 13 denotes feed rolls for transporting the workpiece, and 14 denotes a registration mark detector which detects a registration mark of the workpiece.

The reference numeral 20 denotes a counter, 21 denotes a D/A converter which performs conversion on a command value to the servo driver 2, 22 denotes a differential circuit, and 23 denotes a multiplier. The reference numeral 24 denotes a saw-tooth wave generating circuit which generates a

phase in one cycle of a cut length, 25 denotes the phase, 26 denotes a speed pattern generator for an electronic cam curve, 27 denotes a position pattern generator, 28 denotes a registration mark correcting circuit, 29 denotes a position command, and 30 denotes a position control gain.

Next, the operation will be described.

The first embodiment is used for controlling the rotary cutter which continuously cuts web paper, an iron sheet, or the like that successively travels as shown in Fig. 2, into a preset length and without stopping the travel. As shown in Fig. 3, the rotary cutter 11 is provided with either of straight blades of Fig. 3A, or spiral blades of Fig. 3B depending on the blade attachment shape. Since straight blades require a very high pressure in cutting operation, they are not frequently used. Consequently, spiral blades will be mainly described. With respect to straight blades, therefore, control equations and the like will be described only in a supplemental manner. As shown in Figs. 4A, 4B, 4C, and 4D, in addition to a single blade cutter, a double, triple, or quadruple blade cutter (the number of blades is indicated by M) may be used. These cutters operate in a fundamentally identical manner except that one cycle of the cut length is varied to peripheral length/2, peripheral length/3, or peripheral length/4. Therefore, a single-blade cutter will be described.

In the embodiment, as shown in Fig. 5, an electronic cam control by a continuous correlation control is realized while the end point of a synchronizing zone (cutting zone) is set to the start point $t = 0$ of one cycle and an electronic cam curve including a prediction of the start point of the cutting zone of the next cycle is produced.

In practice, a control due to a cam curve such as shown in Fig. 6 is performed. Fig. 6A shows a speed pattern, Fig. 6B shows a position pattern, zone (1) is a noncutting zone, and zone (2) is a cutting zone. N_1 is a rotational speed in the cutting zone, n_2 is a speed in the noncutting zone, Tc is one cycle time, t_3 is the time of starting the cutting operation, y_1 is the position pattern of the noncutting zone, y_2 is the position pattern of the cutting zone, and Y_1 is the start position of the cutting operation.

With respect to a method of producing such a cam curve, when the radius of the cutter such as that of Fig. 5 = r (mm), the cutting number = N_0 (bpm), the cut length (long or short) = L_0 (mm), and the synchronizing angle = θ_0 (°), the followings are attained:

speed of workpiece (paper or the like) $V_L = N_0 \times L_0/1000$ (m/min)

one cycle time $Tc = 60/N_0$ (sec)

and the speed N_1 at the cutting start point is

$N_1 = 1000 \times V_L/2\pi r$ (rpm).

When the time of the cutting zone is t_0 (sec), the following is obtained from the travel distance of the cutting zone:

$$N_1/60 \times t_0 = \theta_0/360$$

$$\therefore \quad t_0 = \theta_0/6N_1$$

Therefore, a cutting start time $t_3 = Tc - t_0$ (sec) is obtained, and the rotational position at $t = t_3$ is

$Y_1 = 1/M - \theta_0/360$ (rev).

Consequently, the speed and position of the cutter in cutting zone (2) shown in Fig. 6 are obtained as follows:

speed $n_2 = N_1$ (rpm)

position $y_2 = (1/M - Y_1)/(Tc - t_3) \times (t - T_c) + 1/M$ (rev)

where $1/M = 1$ in the case of a single-blade cutter.

By contrast, with respect to noncutting zone (1), a curve equation which satisfies the speed N_1 (rpm) and the position 0 (rev) at the time $t = 0$ shown in Fig. 6, and the speed N_1 (rpm) and the position Y_1 (rev) at the time $t = t_3$ is required.

In general, as shown in Fig. 7A, a cubic function having four coefficients corresponds to a curve equation of positions satisfying four boundary conditions of the speed V_1 and the position X_1 at the time $t = T_1$, and the speed V_2 and the position X_2 at the time $t = T_2$.

Therefore, when

the position is $x = At^3 + Bt^2 + Ct + D$ (rev), (1)

the speed v is obtained by equation (2) which is obtained by differentiating the position

speed $v = 3At^2 + 2Bt + C$ (rps). (2)

When four coefficients (T_1, X_1) and (T_2, X_2) are substituted into equation (1) above, (T_1, V_1) and (T_2, V_2) are substituted into equation (2), and the equations are divided by K and then solved for A, B, C, and D, following equation (3) is obtained.

$A = \{2(X_1 - X_2) - (T_1 - T_2)(V_1 + V_2)\}/K$

$B = [(V_1 - V_2)(T_1 - T_2)(T_1 + 2T_2) - 3(T_1 + T_2)\{X_1 - X_2 - V_2(T_1 - T_2)\}]/K$

$C = \{6(X_1 - X_2)T_1 \bullet T_2 + 3(T_1 + T_2)(V_1 \bullet T_2^2 - V_2 \bullet T_1^2) + 2(T_1^2 + T_1 \bullet T_2 + T_2^2)(V_2 \bullet T_1 - V_1 \bullet T_2)\}/K$

$D = -[(X_1 - V_1 \bullet T_1)T_2^2(3T_1 - T_2) + (X_2 - V_2 \bullet T_2)T_1^2(T_1 - 3T_2) + 2(V_1 - V_2)T_1^2 \bullet T_2^2]/K$

$K = -(T_1 - T_2)^3$. (3)

When the actual pattern coefficients shown in Fig. 6,

$T_1 \rightarrow 0$ (the final time of the cutting zone),

$T_2 \rightarrow t_3$ (the initial time of the cutting zone of the next cycle),

$X_1 \rightarrow 0$ (the position at time T_1),

$X_2 \rightarrow Y_1$ (the position at time $T_2 = t_3$),

$V_1 \rightarrow N_1/60$ (the speed at time $T_1 = 0$), and

$V_2 \rightarrow N_1/60$ (the speed at time t_3)

are substituted into these A, B, C, and D to obtain A, B, C, and D,

$n_1 = 60(3At^2 + 2Bt + C)$ (rpm)

$n_2 = N_1$ (rpm)

$y_1 = At^3 + Bt^2 + Ct + D$ (rev)

$y_2 = (1/M - Y_1)/(Tc - t_3) \times (t - Tc) + 1/M$ (rev)

where $1/M = 1$ in the case of a single-blade cutter are obtained as a cam curve equation of the spiral blade of the rotary cutter.

The cam curve equation of the spiral blade is shown in Fig. 8. This equation completely satisfies the boundary conditions of the speed and position at $t = 0$ and $t = t_3$. Therefore, the same algorithm can automatically cope with the cases of a long cutting operation in which the cut length is larger than the peripheral length, and a short cutting operation in which the cut length is smaller than the peripheral length, and also the case where the line speed is changed. Accordingly, a pattern is drawn in which, as shown in Fig. 6A, in the noncutting zone of region (1), the speed in the short cutting operation is raised in the form of a quadratic function, and conversely that in the long cutting operation is reduced in the form of a quadratic function.

Figs. 9 and 10 show the cam curve equation and the cam curve pattern in the case of a straight blade. With respect to the cum curve of noncutting zone (1), the cam curve for a spiral blade is strictly identical with that for a straight blade except that, in the case of a straight blade, the speed in cutting zone (2) has a pattern which is proportional to $1/\cos\theta$ as shown in Fig. 9A.

Next, the electronic cam control of the rotary cutter which is performed by using the thus obtained speed and position cam curve equations will be further described with reference to Fig. 1.

Pulses output from the measuring roll 12 for detecting the travel distance of a workpiece such as paper or an iron sheet are fetched into the digital controller 1 which performs a constant-period scan control, and then counted by the counter 20a. A phase θ in one cycle where the maximum value is equal to a pulse amount θ_M corresponding to the cut length is repeatedly obtained by the saw-tooth wave generating circuit 24. The phase is input into the position pattern generating circuit 27 and the speed pattern generating circuit 26 which correspond to one cycle by a cam curve such as shown also in Fig. 6 described above, and a position command Yref 29 and a speed command are obtained at every moment.

With respect to the position command Yref, when one cycle is completed, an addition of the maximum position value (the rotational pulse amount of the servo motor 3 corresponding to the cut length) of the one cycle is performed, whereby the rotary cutter 11 is controlled so as to be continuously rotated in the same direction.

With respect to the thus produced position command, a feedback control is performed by using a pulse count value from the pulse generator for the

servo motor 3, and a position control is conducted so as to make the position error ε close to 0, thereby realizing the electronic cam control at every moment.

With respect to the speed pattern, the cam curve equation of Fig. 8 or 10 is previously obtained under the state of 100% of the travelling speed of the paper or the like. V(p, u) which is obtained by normalizing the speed that is actually obtained by the differential circuit 22 is multiplied with an output of the speed pattern generating circuit 26, whereby the speed is used as a feedforward according to the actual travelling speed of the paper or the like, so as to enhance the traceability.

When preprinted paper or the like is to be cut, a registration mark (alignment) which is printed every page simultaneously with printing is detected by the registration mark detector 14, and a position error or the like is corrected by the registration mark correcting circuit 28.

The cam curve equations shown in Figs. 8 and 10 are obtained as those relating to the time t. Alternatively, such an equation may be used in a control while replacing the time with the travel distance of the paper or the like, i.e., the phase θ (pulse).

When the travel distance of the paper or the like is indicated as V_L (mm/s), the travel distance of the paper or the like at the time $t = t_n$ in one cycle is indicated as x_n (mm), the pulse count amount at the same time in one cycle is indicated as P_n (pulses), and the pulse weight is indicated as P_w (mm/p), the followings are obtained:

$$P_n \bullet P_w = V_L \bullet t_n$$

$$P_n = V_L/P_w \times t_n$$

$$= K \times t_n \qquad \text{where } K = V_L/P_W.$$

As a result, the time t_n can be replaced with the pulse count amount P_n (i.e., the phase θ) from the measuring roll 12.

In the control of the conventional art, as shown in the figure of Fig. 24 showing the speed pattern and the torque in the conventional art system, the speed pattern of the noncutting zone shown in Fig. 24A has a trapezoidal waveform, and, in order to satisfy the cycle time and gain the time for stabilizing the speed before the cutting operation, the acceleration or deceleration time is set to be somewhat short as shown in Fig. 24B. Therefore, the peak of a torque required during acceleration or deceleration is high and the root mean square of the torque Trms tends to be large. In a short cutting operation, particularly, the acceleration or deceleration frequency is high, and hence Trms exceeds 100%. In order to prevent this from occurring, the line speed must be lowered, with the result that the productivity is largely impaired.

As shown in the figure of Fig. 14 showing relationships of the line speed with respect to the cut length, the characteristics of the LV curve which is an important index of the productivity of the rotary cutter are largely impaired as indicated by the broken line.

By contrast, Fig. 11 is a view showing the speed pattern and the torque in the invention. In the case of the present embodiment, the speed pattern of noncutting zone (1) is a quadratic curve as shown in Fig. 11A. Therefore, the torque required for acceleration and deceleration is dispersed over the whole of zone (1) as shown in Fig. 11B, and hence improvement is enabled.

Fig. 12 is a view comparing the quadratic functional speed pattern in the invention with the trapezoidal speed pattern in the conventional art. In

the cases where movement over the same distance in a noncutting zone is performed in a quadratic functional speed pattern such as shown in Fig. 12A, and where such movement is performed in a trapezoidal speed pattern such as shown in Fig. 12B, it is assumed that, in order to simplify the description, in the case of the quadratic functional type, a quadratic function which passes t = 0 and 1 and which has the maximum value of 1 is used, and movement of its area S_1 (corresponding to the noncutting zone) is performed. In this case, the equation of the quadratic functional speed is indicated by the following equation:

$$N = -4(t - 0.5)^2 + 1 . \qquad (4)$$

The acceleration α is obtained by differentiating equation (4) as follows:

$$\alpha = dN/dt = -8(t - 0.5). \qquad (5)$$

As shown in equation (6), the travel distance S_1 is obtained by integrating equation (4) from t = 0 to t = 1.

$$\begin{aligned} S_1 &= \int_0^1 \{-4(t-0.5)^2 + 1\}dt \\ &= 2/3 \\ &\cong 0.667 \end{aligned} \qquad (6)$$

When the root mean square of the acceleration α_{rms} is applied as the root mean square of the torque, following equation (7) is obtained:

$$\begin{aligned} \alpha\,\mathrm{rms} &= \sqrt{\int_0^1 \{-8(t-0.5)^2\}dt} \\ &= 4/\sqrt{3} \\ &\cong 2.309 \end{aligned} \qquad (7)$$

In the case of the trapezoidal wave of Fig. 12B, in the case where the acceleration or deceleration time is considered to be $t\alpha = 0.1$, when the maximum value of the speed is Nt, the travel distance S_2 is:

$S_2 = (0.8 + 1) \times Nt/2$.

From $S_1 = S_2$,

$Nt = 0.7407$. (8)

The acceleration is as follows:

when $0 \leq t < 0.1$ $\alpha = 0.7407/0.1 = 7.407$

when $0.1 \leq t < 0.9$ $\alpha = 0$

when $0.9 \leq t \leq 1$ $\alpha = -7.407$. (9)

Equation (9) contains three αs.

From equation (9), the root mean square of the acceleration is obtained as equation (10):

$$\alpha_{rms} = \sqrt{(7.407)^2 \times 0.1 + (-7.407)^2 \times 0.1} = 3.312 \qquad (10)$$

From the above calculation, equation (7) of the root mean square in a quadratic function waveform, and equation (10) in the case of a trapezoidal waveform are in the relationship of (7) < (10), or α_{rms} of the quadratic function is smaller than that of the trapezoidal waveform.

In this example, the acceleration time in the case of a trapezoidal waveform is considered to be $t\alpha = 0.1$. Fig. 13 is a view showing a speed pattern which is obtained by generalizing the trapezoidal waveform shown in Fig. 12 while assuming that $0 < t\alpha < 0.5$ is possible. When the acceleration or

deceleration time is generalized and considered to be $t\alpha$ in this way, the travel distance S_2 in Fig. 13 is:

$$S_2 = \{(1 - 2t\alpha) + 1\} \times Nt/2.$$

Since $S_1 = S_2$, the following is obtained:

$$Nt = 2/3(1 - t\alpha). \tag{11}$$

The acceleration is as follows:

when $0 \leq t < t\alpha$ $\alpha = Nt/t\alpha$

when $t\alpha \leq t < (1 - t\alpha)$ $\alpha = 0$

when $(1 - t\alpha) \leq t \leq 1$ $\alpha = -Nt/t\alpha$. (12)

Equation (12) contains three αs.

From equation (12), the root mean square of the acceleration is obtained as equation (13):

$$\begin{aligned}\alpha_{rms} &= \sqrt{(Nt / t\alpha)^2 \cdot t\alpha + (-Nt / t\alpha)^2 \cdot t\alpha} \\ &= 2/3(1 - t\alpha) \times \sqrt{2 / t\alpha}\end{aligned} \tag{13}$$

In order to obtain $t\alpha$ which gives the minimum value of equation (13), $d\alpha_{rms}/dt\alpha = 0$ is set, and then the following is obtained:

$$t\alpha = 1/3. \tag{14}$$

Therefore, the minimum value becomes as equation (15):

$$\begin{aligned}\alpha_{rms}\Big|_{t\alpha = 1/3} &= \sqrt{6} \\ &\cong 2.45\end{aligned} \tag{15}$$

From the above, in the range of $0 < t\alpha < 0.45$ and in the case of a

trapezoidal wave as shown in Fig. 13B,

$$\alpha_{rms} \geq 2.45$$

is obtained.

Even in this case, therefore, (7) < (15) is obtained, or, even when the speed pattern of a trapezoidal wave is set to have any acceleration or deceleration time, the root mean square of the torque of a speed pattern of a quadratic function is smaller.

As a result, in the LV curve of Fig. 14, according to the trapezoidal waveform of the conventional system, the line speed in the case of a short cutting operation must be earlier lowered, but, according to the system of the invention, the cutting operation can is improved so as to be enabled at 100% of the line speed even in a considerably short range. Therefore, the productivity can be improved as compared with the trapezoidal waveform system of the conventional art. As described above, the acceleration or deceleration time $t\alpha$ in the case of a speed pattern of a trapezoidal waveform in the conventional art is usually set to be somewhat short. Consequently, this effect is particularly large.

Next, a second embodiment of the invention will be described with reference to the figures.

Figs. 15 to 19 are views relating to the second embodiment of the invention.

Referring to Fig. 15, 41 denotes a digital controller which performs a constant scan control, 42 denotes a servo driver which drives a servo motor 43, 44 denotes a pulse generator for the motor 43, 45 denotes a line PG which detects a line speed for transporting a workpiece such as paper or a film, and

46a and 46b denote lateral sealing mechanisms of a packaging machine which has heating faces and which seals sealing faces.

The reference numerals 50a and 50b denote counters, 51 denotes a D/A converter which performs conversion on a command value to the servo driver 2, 52 denotes a differential circuit, 53 denotes a divider, 54 denotes a multiplier, 55 denotes a saw-tooth wave generating circuit which generates a phase in one cycle of sealing, 56 denotes the phase, 57 denotes a speed pattern generator for an electronic cam curve, 58 denotes a position pattern generator, 59 denotes a position command, and 60 denotes a position control gain.

Next, the operation will be described.

As the lateral sealing mechanism of a vertical continuous packaging machine such as shown in Fig. 16 which is the second embodiment, there are single-heater lateral sealing mechanisms of Fig. 16A, or double-heater lateral sealing mechanisms of Fig. 16B. The mechanisms are driven by the servo motor 43. In order to continuously perform lateral sealing without stopping the bag-like film or the like, the lateral sealing mechanisms in each of which a heater face in the tip end constitutes a part of a circumference are arranged so as to be bilaterally symmetrical, and lateral heaters press the film under a state where the peripheral speed is equal to the film speed, whereby lateral sealing for a predetermined time (sealing time) is realized.

Fig. 17 shows positional relationships in the case of the double heating faces 46 in the lateral sealing mechanism. In theory, the number of heaters may be considered to be plural or 3, 4, ..., and hence the consideration will be made while generalizing as the face number M (M = 1, 2, ...).

In the embodiment, as shown in Fig. 17, an electronic cam control by a continuous correlation control is realized while the end point of a sealing zone is set to the start point $t = 0$ of one cycle and a cam curve including a prediction of the start point of the sealing zone of the next cycle is produced.

In practice, a control due to a cam curve pattern such as shown in Fig. 18 is performed. Fig. 18A shows a speed pattern, Fig. 18B shows a position pattern, zone (1) is a nonsealing zone, and zone (2) is a sealing zone. N_1 is a rotational speed in the sealing zone, n_2 is a speed in the nonsealing zone, Tc is one cycle time, t_3 is the time of starting the sealing operation, y_1 is the position pattern of the nonsealing zone, y_2 is the position pattern of the sealing zone, and Y_1 is the start position of the sealing operation.

With respect to a method of producing such a cam curve, as shown in Fig. 17, when the radius of the lateral sealing mechanism = r (mm), the number of bags to be formed = N_0 (bpm), the bag length = L_0 (mm), and the synchronizing angle = θ_0 (°), the followings are attained:

speed of the film or the like $V_L = N_0 \times L_0/1000$ (m/min)

one cycle time $Tc = 60/N_0$ (sec)

and

the speed N_1 at the sealing start point is

$N_1 = 1000 \times V_L/2\pi r$ (rpm).

When the time of the sealing zone is t_0 (sec), the following is obtained from the travel distance of the sealing zone:

$$N_1/60 \times t_0 = \theta_0/360$$

$$\therefore \quad t_0 = \theta_0/6N_1$$

Therefore, a sealing start time $t_3 = Tc - t_0$ (sec) is obtained, and the

rotational position at $t = t_3$ is

$$Y_1 = 1/M - \theta_0/360 \qquad \text{(rev).}$$

Consequently, the rotational speed and position of the lateral sealing mechanism in sealing zone (2) shown in Fig. 18 are obtained as follows:

rotational speed $n_2 = N_1$ (rpm)

rotational position $y_2 = (1/M - Y_1)/(Tc - t_3) \times (t - T_c) + 1/M$.

By contrast, with respect to nonsealing zone (1), a curve equation which satisfies the speed N_1 (rpm) and the position 0 (rev) at the time $t = 0$ shown in Fig. 18, and the speed N_1 (rpm) and the position Y_1 (rev) at the time $t = t_3$ is required.

In a similar procedure as that of the first embodiment, as shown in Fig. 7A in the previous embodiment, a cubic function having four coefficients corresponds to a curve equation of positions satisfying four boundary conditions of the speed V_1 and the position X_1 at the time $t = T_1$, and the speed V_2 and the position X_2 at the time $t = T_2$.

In a similar manner, therefore, when

the position is $x = At^3 + Bt^2 + Ct + D$ (rev), (1)

the speed v is obtained by equation (2) which is obtained by differentiating the position

speed $v = 3At^2 + 2Bt + C$ (rps). (2)

When four coefficients (T_1, X_1) and (T_2, X_2) are substituted into equation (1) above, (T_1, V_1) and (T_2, V_2) are substituted into equation (2), and the equations are divided by K and then solved for A, B, C, and D, (A, B, C, D) of following equation (3) are obtained.

$$A = \{2(X_1 - X_2) - (T_1 - T_2)(V_1 + V_2)\}/K$$

$$B = [(V_1 - V_2)(T_1 - T_2)(T_1 + 2T_2) - 3(T_1 + T_2)\{X_1 - X_2 - V_2(T_1 - T_2)\}]/K$$

$$C = \{6(X_1 - X_2)T_1 \bullet T_2 + 3(T_1 + T_2)(V_1 \bullet T_2^2 - V_2 \bullet T_1^2) + 2(T_1^2 + T_1 \bullet T_2 + T_2^2)(V_2 \bullet T_1 - V_1 \bullet T_2)\}/K$$

$$D = -[(X_1 - V_1 \bullet T_1)T_2^2(3T_1 - T_2) + (X_2 - V_2 \bullet T_2)T_1^2(T_1 - 3T_2) + 2(V_1 - V_2)T_1^2 \bullet T_2^2]/K$$

$$K = -(T_1 - T_2)^3. \qquad (3)$$

When the actual pattern coefficients shown in Fig. 18, $T_1 \rightarrow 0$ (the final time of the sealing zone), $T_2 \rightarrow t_3$ (the initial time of the sealing zone of the next cycle), $X_1 \rightarrow 0$ (the position at time T_1), $X_2 \rightarrow Y_1$ (the position at time $T_2 = t_3$), $V_1 \rightarrow N_1/60$ (the speed at time $T_1 = 0$), and $V_2 \rightarrow N_1/60$ (the speed at time t_3) are substituted into these A, B, C, and D to obtain A, B, C, and D,

$$n_1 = 60(3At^2 + 2Bt + C) \qquad \text{(rpm)}$$

$$n_2 = N_1 \qquad \text{(rpm)}$$

$$y_1 = At^3 + Bt^2 + Ct + D \qquad \text{(rev)}$$

$$y_2 = (1/M - Y_1)/(Tc - t_3) \times (t - Tc) + 1/M \qquad \text{(rev)}$$

are obtained as a cam curve equation of the lateral sealing mechanism such as shown in Fig. 19.

The cam curve equation of the lateral sealing mechanism 46 is shown in Fig. 19. This equation completely satisfies the boundary conditions of the speed and position at $t = 0$ and $t = t_3$. As shown in Fig. 18, therefore, the speed in the case of the bag length = (peripheral length/M) is N_1 (constant), that in the case of the bag length < (peripheral length/M) is raised in the form of a quadratic function, and that in the case of the bag length > (peripheral length/M) is reduced in the form of a quadratic function.

In the embodiment, the above can be automatically realized. Even

when conditions are changed or, for example, the length of a bag to be formed is changed, the simultaneous equations in four unknowns are solved by the controller 41, and a new cam curve (position pattern, speed pattern) is obtained in a moment to realize a control of an excellent traceability.

Next, the electronic cam control of the lateral sealing mechanism 46 which is performed by using the thus obtained speed and position cam curve equations will be further described with reference to Fig. 15.

Pulses output from the line PG 45 for detecting the travel distance of a film, paper, or the like are fetched into the digital controller 41 which performs a constant-period scan control, and then counted by the counter 50a. A phase θ in one cycle where the maximum value is equal to a pulse amount θ_M corresponding to the bag length is repeatedly obtained by the saw-tooth wave generating circuit 55. The phase is input into the position pattern generating circuit 58 and the speed pattern generating circuit 57 which correspond to one cycle described above, and a position command Yref 59 and a speed command are obtained at every moment.

With respect to the position command Yref, when one cycle is completed, an addition of the maximum position value (the rotational pulse amount of the servo motor 43 corresponding to 1/Mrev of the lateral sealing mechanism) of the one cycle is performed, whereby the lateral sealing mechanism 46 is controlled so as to be continuously rotated in the same direction.

With respect to the thus produced position command, a feedback control is performed by using a pulse count value from the pulse generator 44 for the servo motor 43, and a position control is conducted so as to make the position error ε close to 0, thereby realizing the electronic cam control at every moment.

With respect to the speed pattern, the cam curve equation of Fig. 19 is previously obtained under the state of 100% of the travelling speed of the film, paper or the like. V(p, u) which is obtained by dividing the speed V that is actually obtained by the differential circuit 52, with 100% of the speed V (100%) is multiplied with an output of the speed pattern generating circuit 57, whereby the speed is used as a feedforward according to the actual travelling speed of the actual film, paper or the like, so as to enhance the traceability.

The cam curve equation shown in Fig. 19 is obtained as that relating to the time t. Alternatively, such an equation may be used in a control while replacing the time with the travel distance of the film, paper or the like, i.e., the phase θ (pulse).

When the travel distance of the film or the like is indicated as V_L (mm/s), the travel distance of the film or the like at the time $t = t_n$ in one cycle is indicated as x_n (mm), the pulse count amount at the same time in one cycle is indicated as P_n (pulses), and the pulse weight is indicated as P_w (mm/p), the followings are obtained:

$$P_n \bullet P_w = V_L \bullet t_n$$

$$P_n = V_L/P_w \times t_n$$

$$= K \times t_n \qquad \text{where } K = V_L/P_W.$$

As a result, the time t_n can be replaced with the pulse count amount P_n (i.e., the phase θ) from the measuring roll 12.

As described above, the embodiment has a very high traceability and can cope with a change in conditions in a completely automatic manner. In a conventional art system, a lateral sealing mechanism is coupled to a driving shaft for transporting a workpiece such as a film, and driven at constant

rotation. In the single-heater type, therefore, only a bag of a length which corresponds to a circumference can be sealed, and, in a double-heater lateral sealing mechanism of the 180° symmetric type, only a bag of a length which corresponds to a half circumference can be sealed. When a bag of another length is to be sealed, the lateral sealing mechanism must be replaced with one having a different radius. In the case where a bag of a length other than a circumference or a half circumference is to be sealed, therefore, the preparation time is long and the workability is lowered. By contrast, the embodiment is enabled by the electronic cam to rapidly automatically cope with all bag lengths. Therefore, the cost can be remarkably reduced, and the productivity can be improved.

Industrial Applicability

As described above, according to the invention, in a method of controlling an electronic cam type rotary cutter, a position loop is formed in a whole region on the basis of an electronic cam curve, an electronic cam curve of a cubic function is used as a position pattern for a noncutting zone, and an electronic cam curve of a quadratic function is used as a speed pattern, whereby a control is enabled with causing a same algorithm to automatically cope with long and short cutting operations and a change of a line speed. Therefore, the electronic cam control using an electronic cam curve in which the position pattern in a noncutting zone is a cubic function and the speed pattern is a quadratic function produces effects that a control due to the same algorithm can automatically cope with both long and short cut lengths or bag lengths and a change in conditions, that its traceability is largely enhanced,

and that the control efficiency of the rotary cutter is improved.

In a method of controlling a rotary cutter, a position loop is formed in a whole region on the basis of an electronic cam curve, an electronic cam curve of a cubic function is used as a position pattern for a noncutting zone, and an electronic cam curve of a quadratic function is used as a speed pattern, whereby necessity of reduction of the line speed is eliminated even in a length range which is shorter than a range of a conventional art, and a cutting operation is enabled while maintaining the line speed to 100%. In a short cutting operation, the cutting is enabled without reducing the speed, thereby producing an effect that the productivity can be largely improved.

After driven by a servomotor, and performing a sealing work, a cutting work, or the like in synchronization with a workpiece such as a film or paper in a specific phase zone of one cycle of a rotary mechanism, a cubic function is used in a position command according to a continuous correlation control system including a prediction to a start of a work in a next cycle, and a quadratic function is used in a speed feedforward, whereby an optimum electronic cam curve is obtained while allowing a bag length or a cut length of the workpiece to automatically perform correspondence irrespective of a value of peripheral length/M. Therefore, after a sealing work, a cutting work, or another work is performed, position and speed patterns including a prediction to a sealing or cutting start position in a next cycle are uniquely obtained, and there is an effect that an optimum cam curve is automatically obtained while allowing a bag length or a cut length to automatically perform correspondence irrespective of the size relationship of peripheral length/M.

CLAIMS

1. (Amended) In an electronic cam schemed rotary cutter control method to be driven by a servo motor and position-controlled by different position patterns based on an electronic cam curve during long cutting and during short cutting, the electronic cam schemed rotary cutter control method characterized in that:

position control is carried out at all times in every region on the basis of an electronic cam curve wherein the electronic cam curve in a cubic function is used as a position command for a non-cutting section thereby realizing control extremely reduced in positional deviation in entire region including during cutting.

2. (Amended) In an electronic cam schemed rotary cutter control method to be position controlled by different position patterns based on an electronic cam curve during long cutting and during short cutting and during short cutting a line-velocity is reduction-controlled, the electronic cam schemed rotary cutter control method characterized in that:

position control is carried out at all times in every region on the basis of an electronic cam curve wherein the electronic cam curve in a cubic function as a position command for a non-cutting section with a resulting velocity in a quadratic function is used to decrease a torque effective value of a cutter servo motor and eliminates the necessity of reducing the line velocity down to a shorter size than the conventional, thereby making possible cutting by keeping a line velocity of 100%.

3. (Amended) An electric cam schemed rotary cutter control metho as claimed in claim 1 or 2, wherein as a result of a spiral edge cam curve diagram a velocity pattern, in a cutting section, is the same a the line velocity but, in non-cutting section, rises to form an upward-convex quadratic curve during short cutting and decreases in a downward-convex quadratic curve during long cutting, wherein the velocity pattern of a straight edge is in a different pattern that th velocity in the cutting section only is proportional to 1/cos θ (θ representing an angle of the edge from the immediately below during cutting) as compared to the velocity pattern of the spiral edge.

4. (Amended) An electronic cam curve generating method, characterized in that after a work is done of sealing or cutting in tune with a work-piece in a particular phase section in one cycle of rotary mechanism as with a horizontal seal mechanism of a continuous vertical wrapping machine to be driven by a servo motor or rotary cutter for cutting a work-piece to a constant length, position contro is performed using a cubic function for a position command by a continuous correlation control scheme including a prediction up to a next-cycle work start and a quadratic function obtained by differentiating a position command formula for velocity feed forward, whereby a bag length or cut length of the work-piece is automatically corresponded to regardless of an extent of a circumferential length per M (M=1. 2. ..., seal surface count or edge count) thereby obtaining an optimal electronic cam curve having a positional deviation extremely reduced in an entire section including during cutting.

5. (Amended) An electronic cam curve generating method as claime in claim 4, wherein provided that a rotation velocity of a horizontal seal mechanism or cutting tool in a seal section or cutting section i n^2, a position of rotation is y2, a line velocity at a start point is N_1, a position of rotation at a cutting start point is Y1, a time of cutting start point is t_3 and one cycle time is Tc, then

$n_2 = N_1$ (rpm)

$y_2 = (1/M - Y_1) / (Tc - t_3) \times (t - Tc) + 1/M$ (rev);

a curve formula for the non-seal section or non-cutting section being given by a cubic function having four coefficients satisfying four boundary conditions of velocities V_1, V_2 at times T1, T2 and positions X_1, X_2, and a position and a velocity v the position is differentiated are expressed as

$x = At^3 + Bt^2 + Ct + D$ (rev)

$v = 3At^2 + 2Bt + C$ (rps);

the foregoing (T_1, X_1), (T_2, X_2) being substituted for Formula x and the foregoing (T_1, X_1), (T_2, X_2) being substituted for Formula v, solve A, B, C and D, while $T_1 = 0$, $T_2 = t_3$, $X_1 = 0$, $X_2 = Y_1$, $V_1 = N_1/60$ and $V_2 = N_1/60$ are substituted to solve A, B, C and D; whereby

a cam curve formula having a rotation velocity in the non-seal section or non-cutting section = n_1, a rotation position y_1, a rotatic velocity in the seal section or cutting section = n2 and a rotation position = y_2 being obtained as

$n_1 = 60$ (3At2 + 2Bt + C) (rpm)

n2 = N1 (const.) (rpm)

y1 = At3 + Bt2 + Ct + D (rev)

$$y_2 = (1/M - Y_1) / (Tc - t_3) \times (t - Tc) + 1/M \qquad \text{(rev)},$$

whereby a non-cut-section position instruction formula and a velocity feed forward formula being obtained by merely providing four boundary conditions of a cutter edge position and velocity at a time of cut completion and a cutter edge position and velocity at a next time of cut start.

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FIG. 1

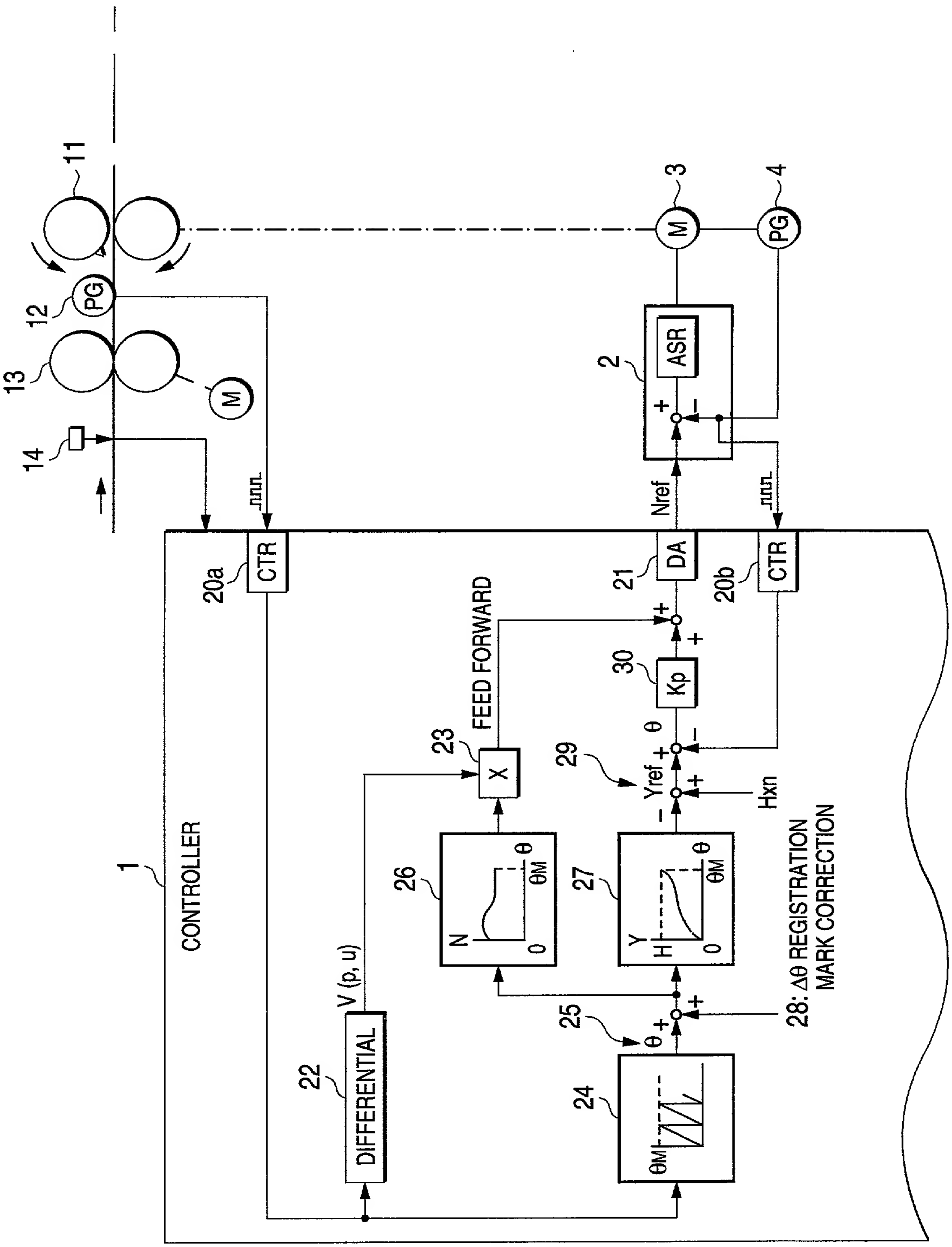

FIG. 2

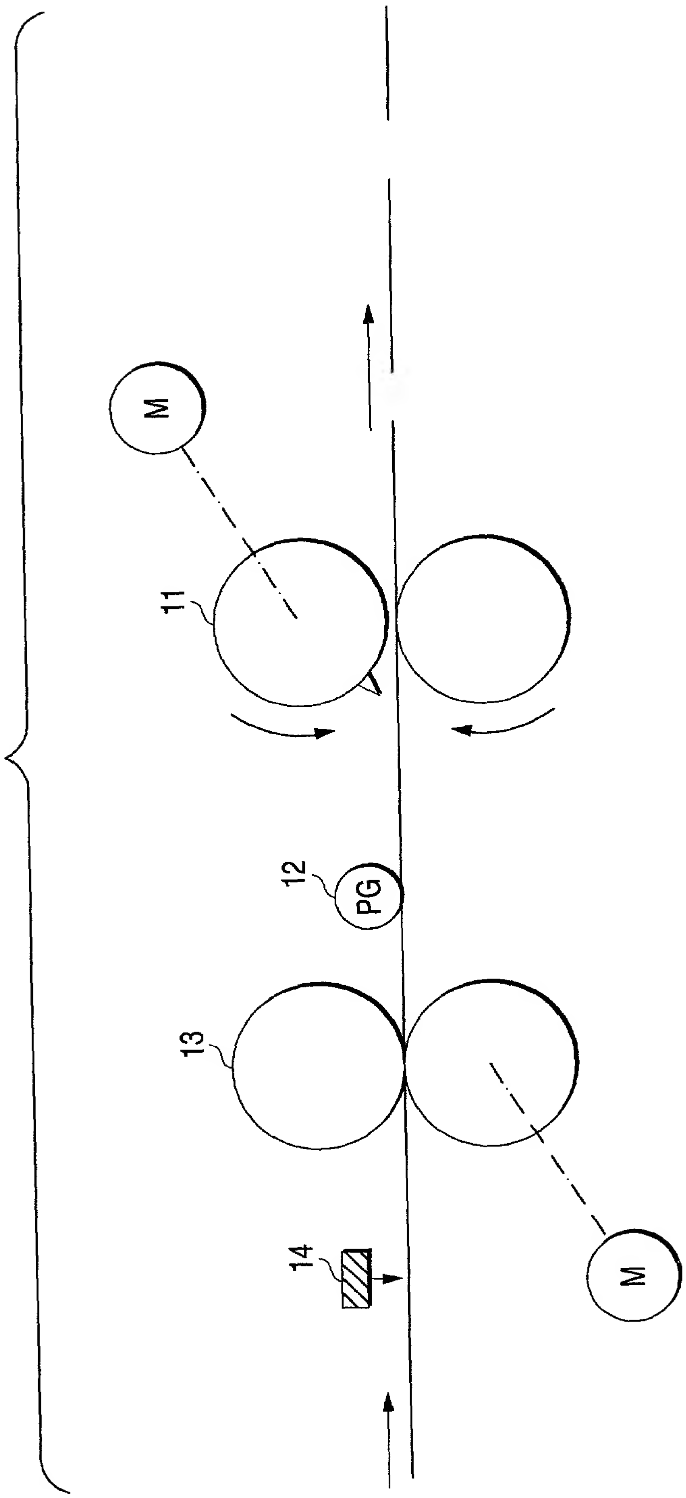

FIG. 3A

STRAIGHT BLADE

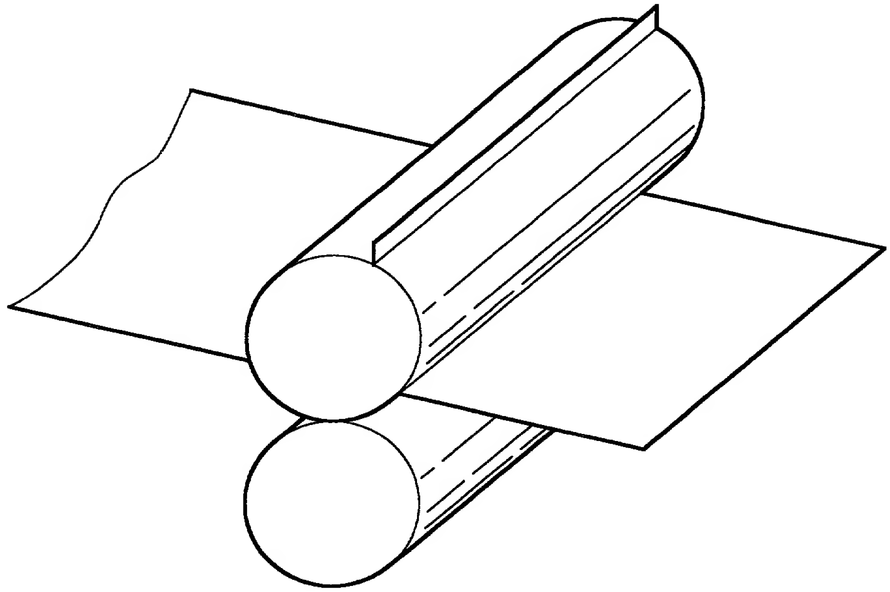

FIG. 3B

SPIRAL BLADE

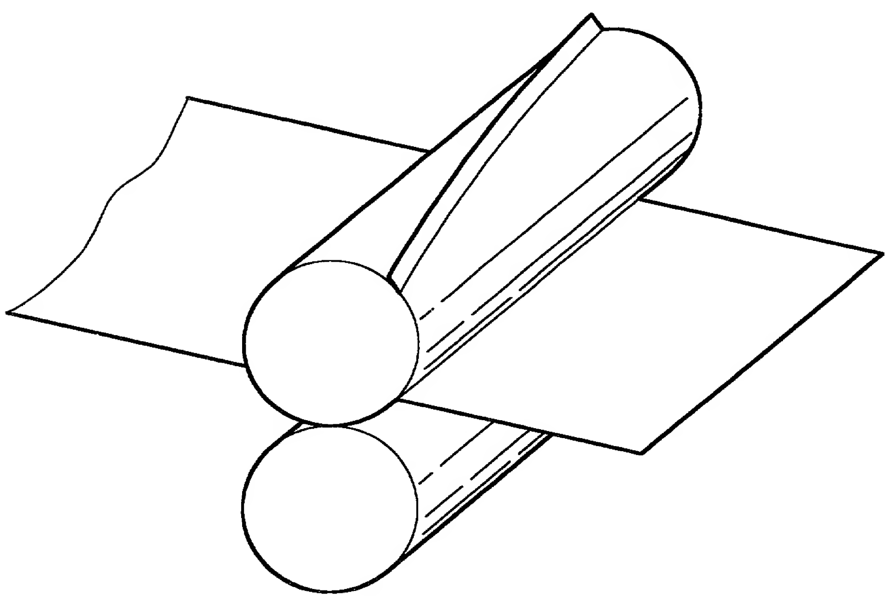

FIG. 4A

SINGLE BLADE

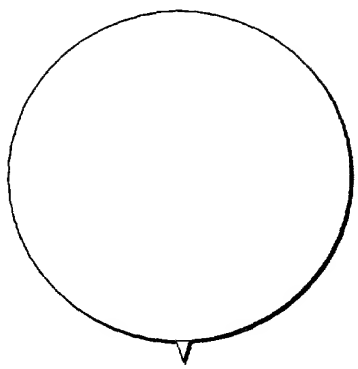

FIG. 4B

DOUBLE BLADE

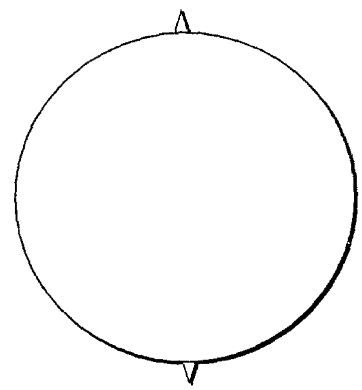

FIG. 4C

TRIPLE BLADE

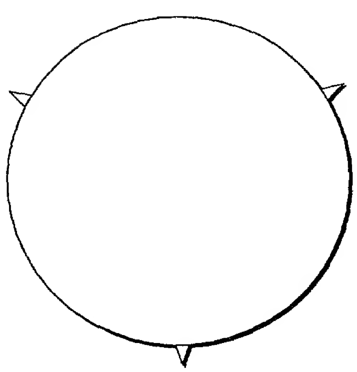

FIG. 4D

QUADRUPLE BLADE

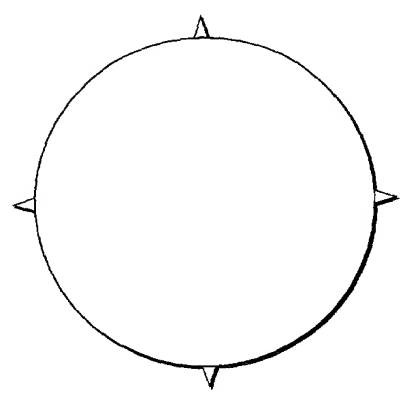

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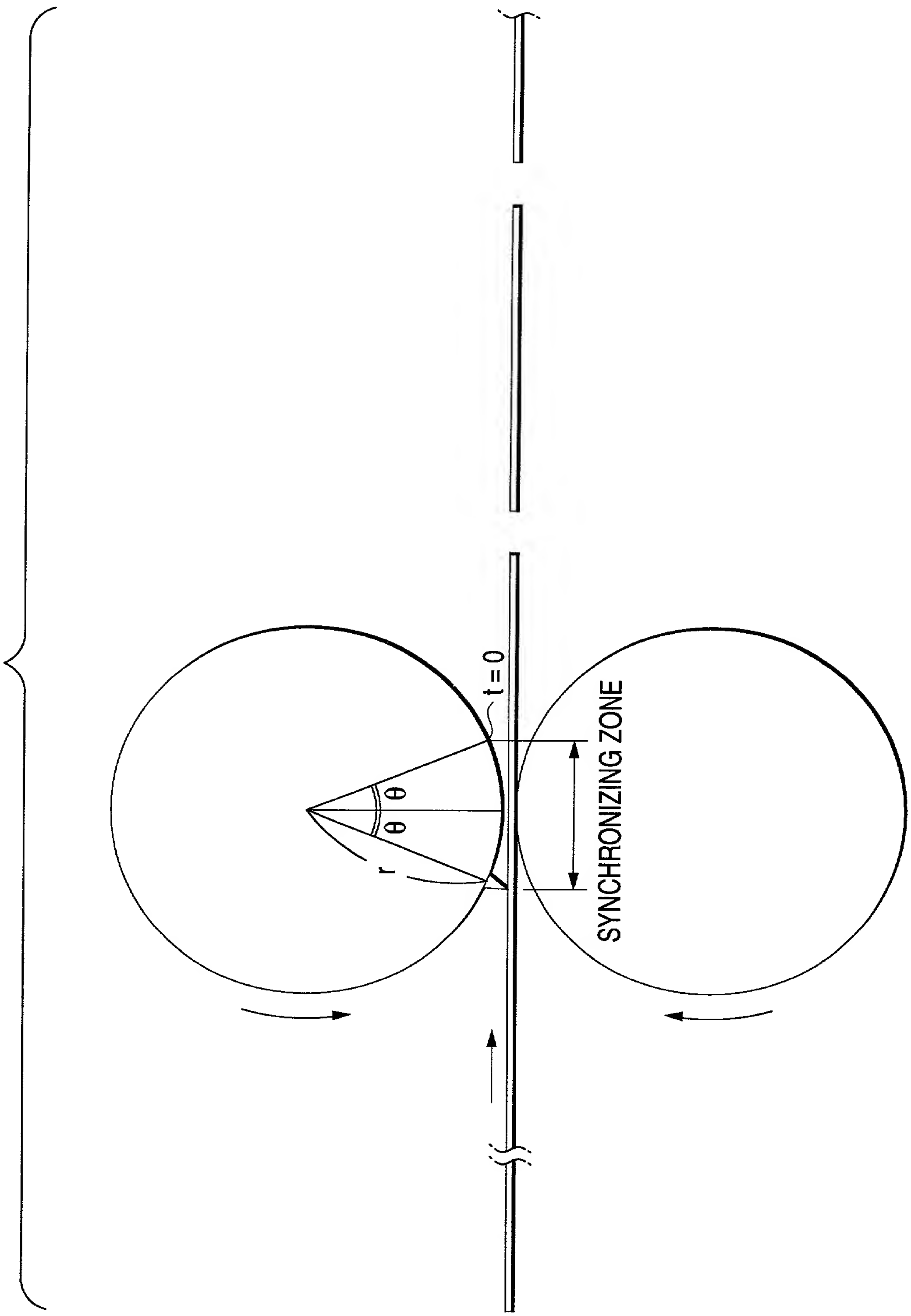
FIG. 5



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[CASE OF SPIRAL BLADE]

FIG. 6A

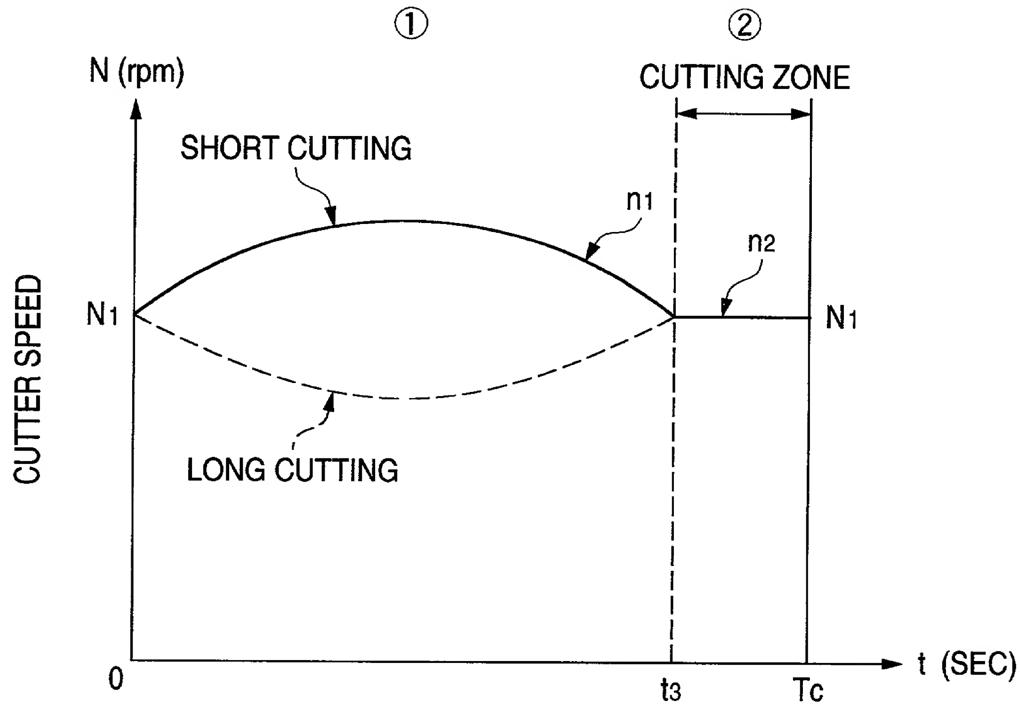

FIG. 6B

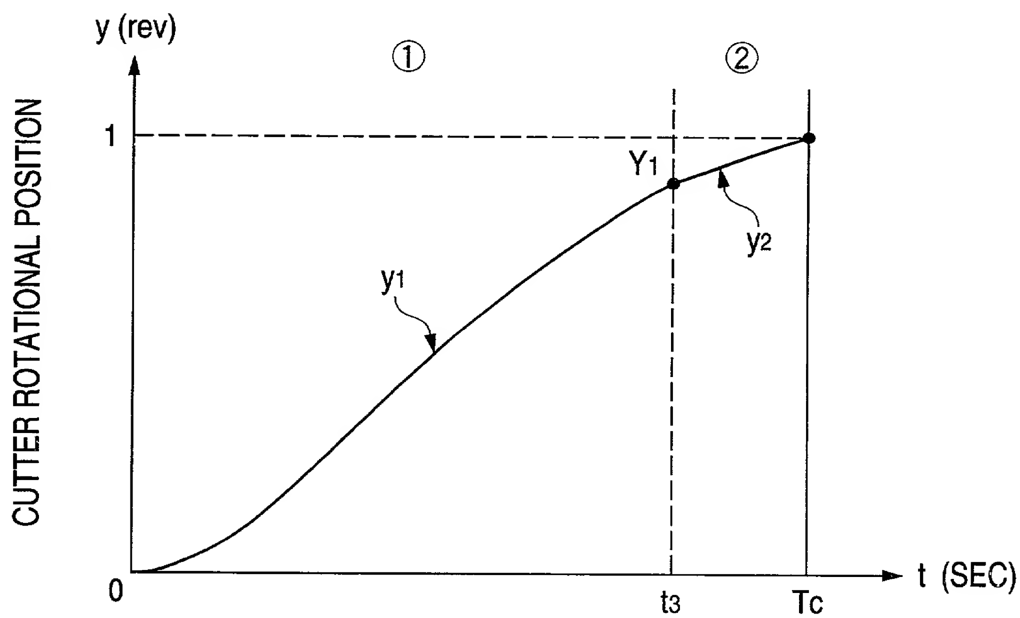

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FIG. 7A

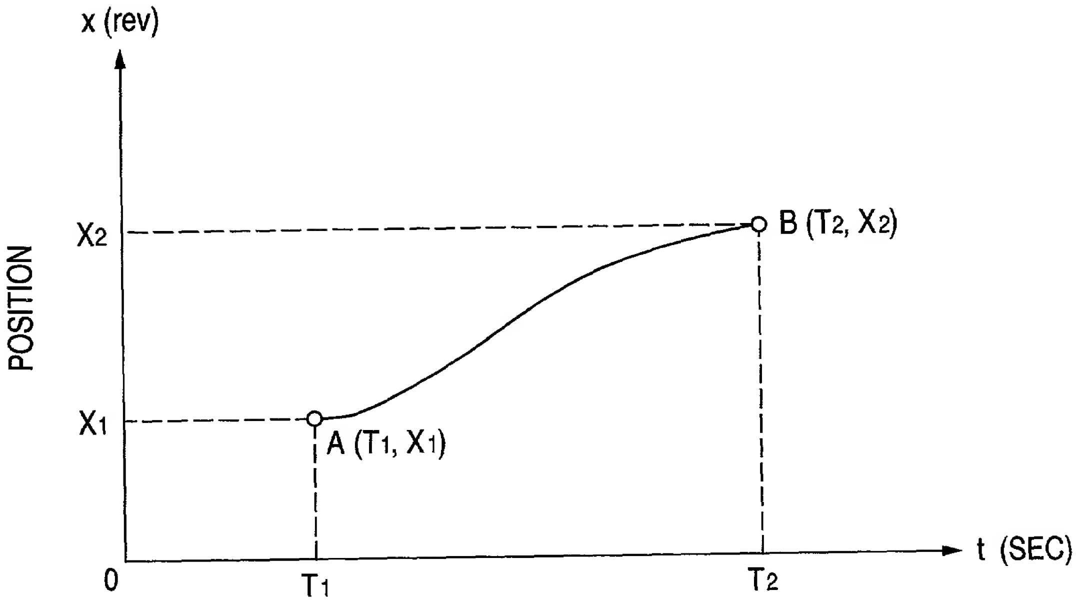
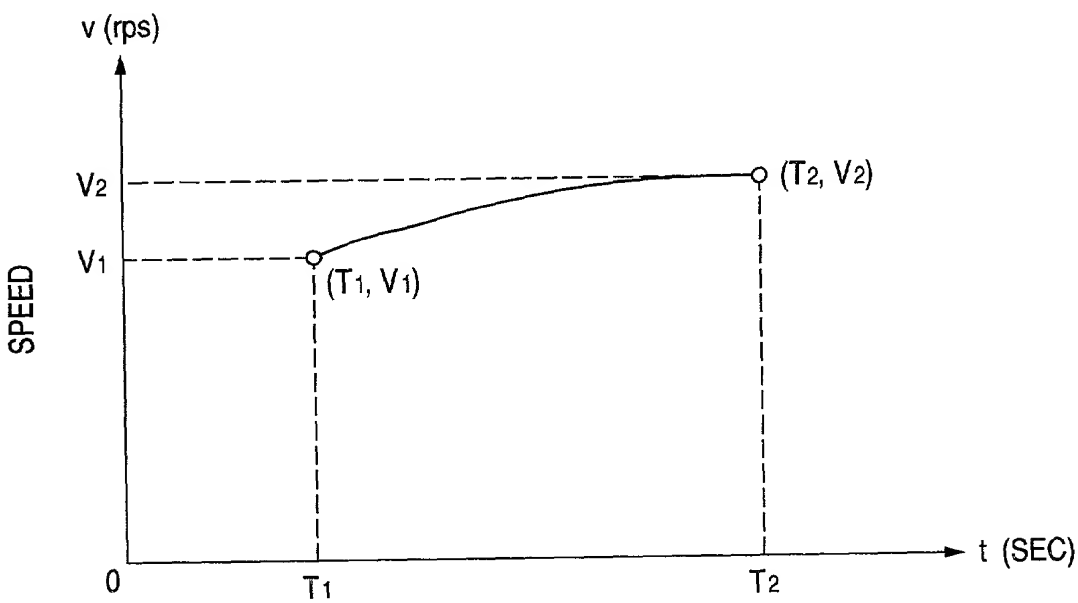


FIG. 7B



09/889047

FIG. 8

(CAM CURVE EQUATIONS OF SPIRAL BLADE)

ZONE	CUTTER ROTATIONAL SPEED n (rpm)	CUTTER ROTATIONAL POSITION y (rev)
①	$n_1 = 60\,(3At^2 + 2Bt + C)$	$y_1 = At^3 + Bt^2 + Ct + D$
②	$n_2 = N_1$	$y_2 = \frac{(1 - Y_1)}{(Tc - t_3)}\,(t - Tc) + 1$

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[CASE OF STRAIGHT BLADE]

FIG. 9A

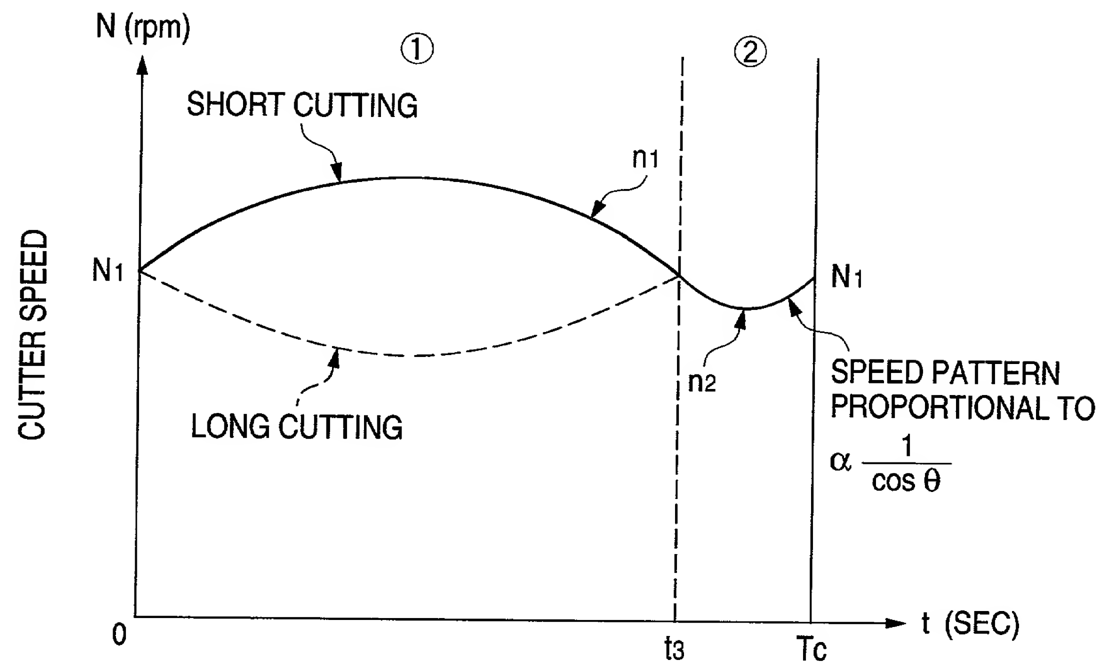
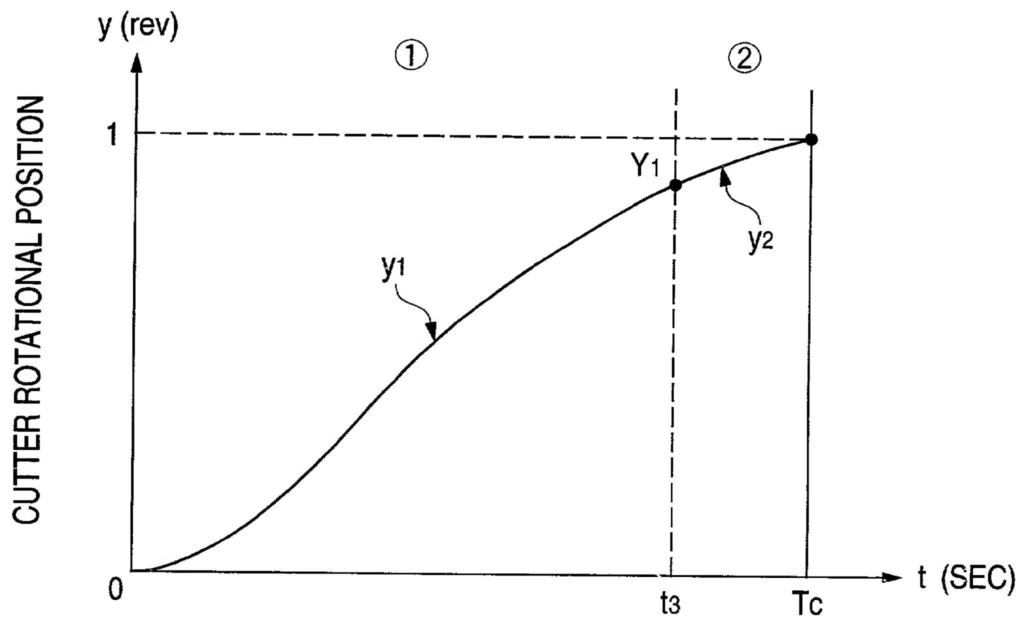


FIG. 9B



09/889047

FIG. 10

(CAM CURVE EQUATIONS OF STRAIGHT BLADE)

ZONE	CUTTER ROTATIONAL SPEED n (rpm)	CUTTER ROTATIONAL POSITION y (rev)
①	$n_1 = 60\,(3At^2 + 2Bt + C)$	$y_1 = At^3 + Bt^2 + Ct + D$
②	$n_2 = \dfrac{60}{2\pi\sqrt{(\frac{r}{V_0})^2 - (t - \frac{t_3 + T_c}{2})^2}}$	$y_2 = \dfrac{1}{360}\sin^{-1}\{(\frac{V_0}{r})(t - \frac{t_3 + T_c}{2})\} + G$ $\left(\begin{array}{l} G = 1 - \frac{\theta_0}{360} \\ \text{UNIT OF } \sin^{-1} x\text{: } (^\circ) \end{array}\right)$

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FIG. 11A

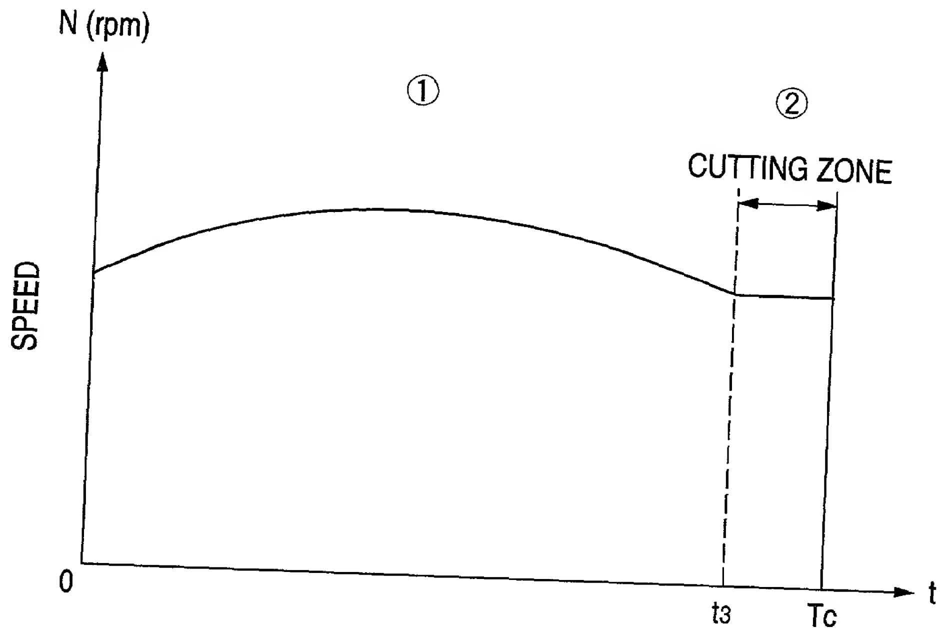

FIG. 11B

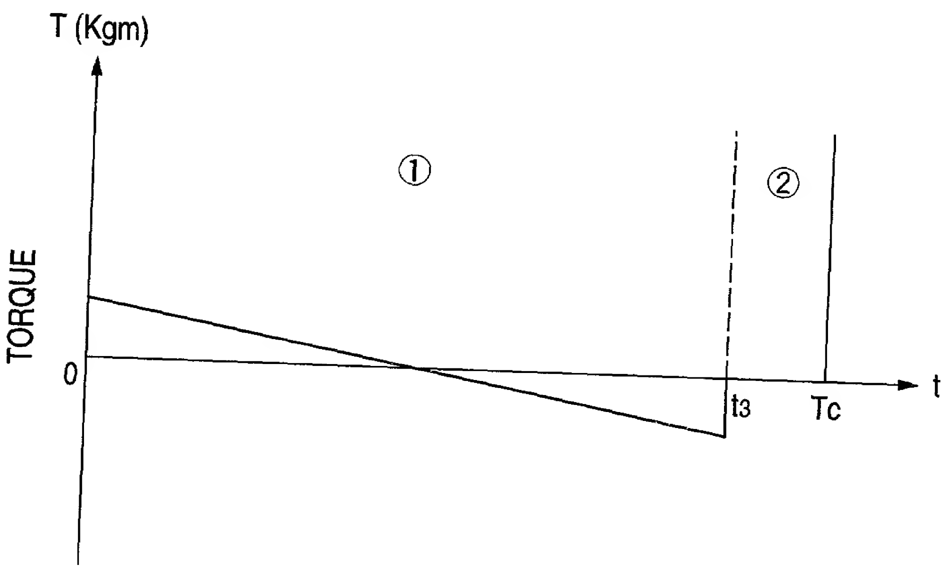

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FIG. 12A

[SPEED PATTERN OF QUADRATIC FUNCTION WAVEFORM]

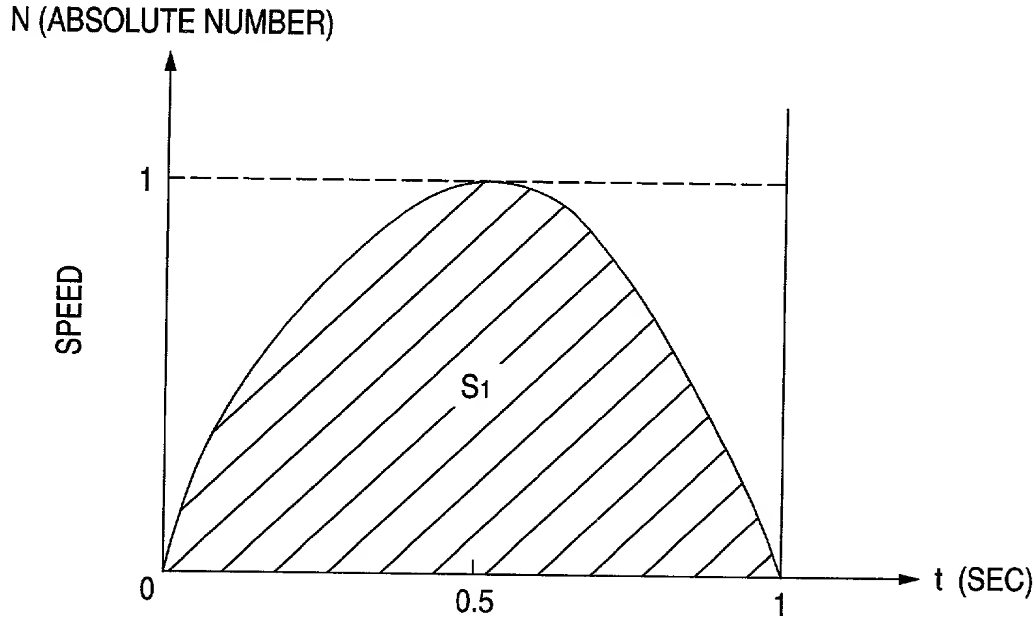
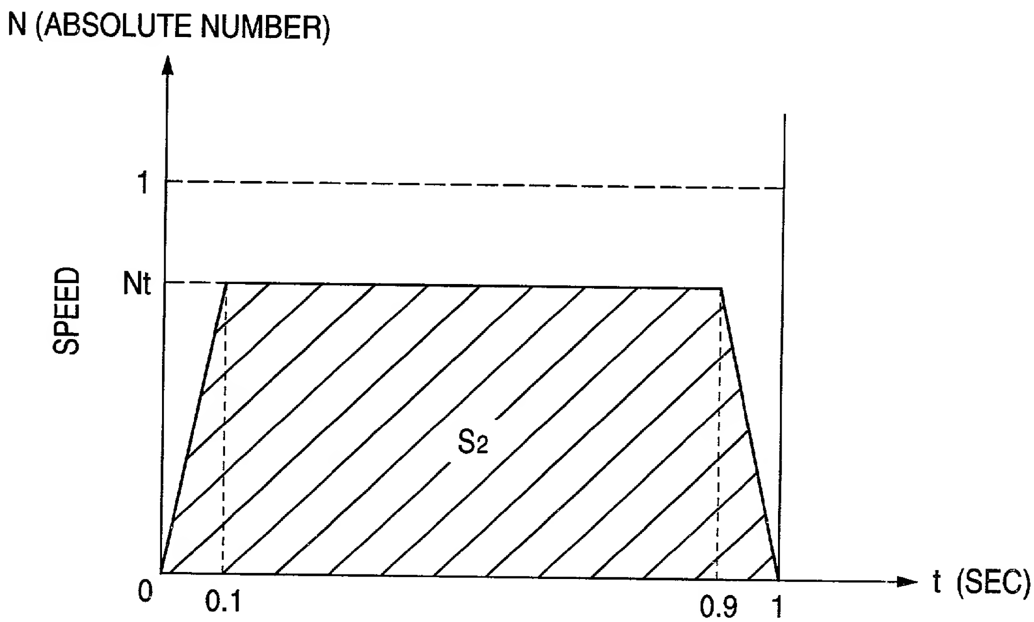


FIG. 12B

[SPEED PATTERN OF TRAPEZOIDDAL WAVEFORM]



09/889047

FIG. 13A

[SPEED PATTERN OF GENERALIZED TRAPEZOIDAL WAVEFORM]

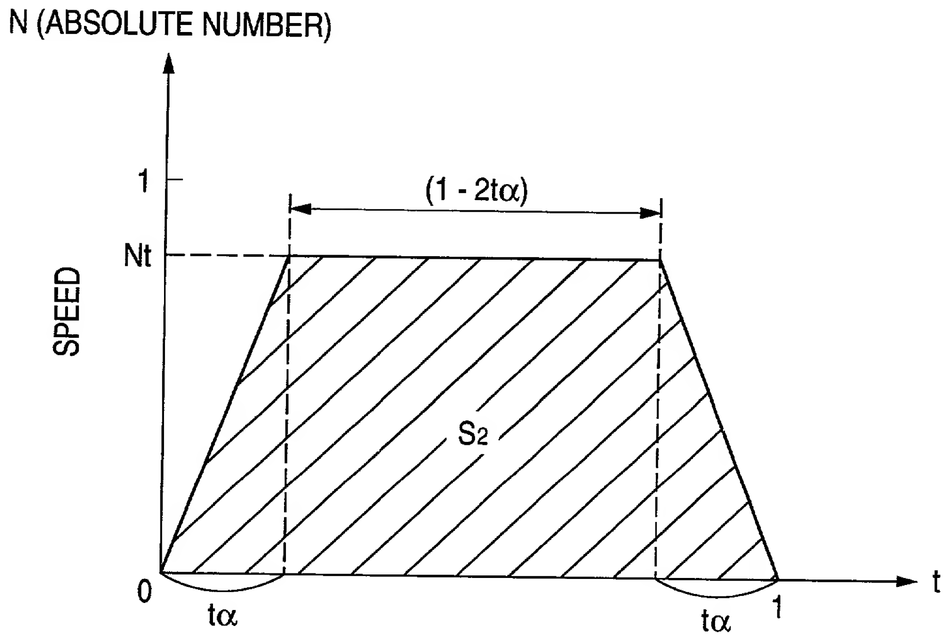


FIG. 13B

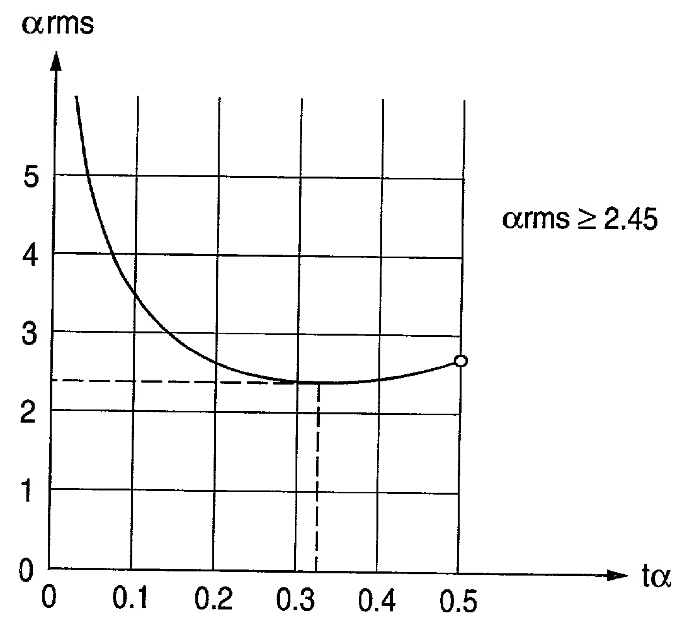


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FIG. 14

LV CURVE

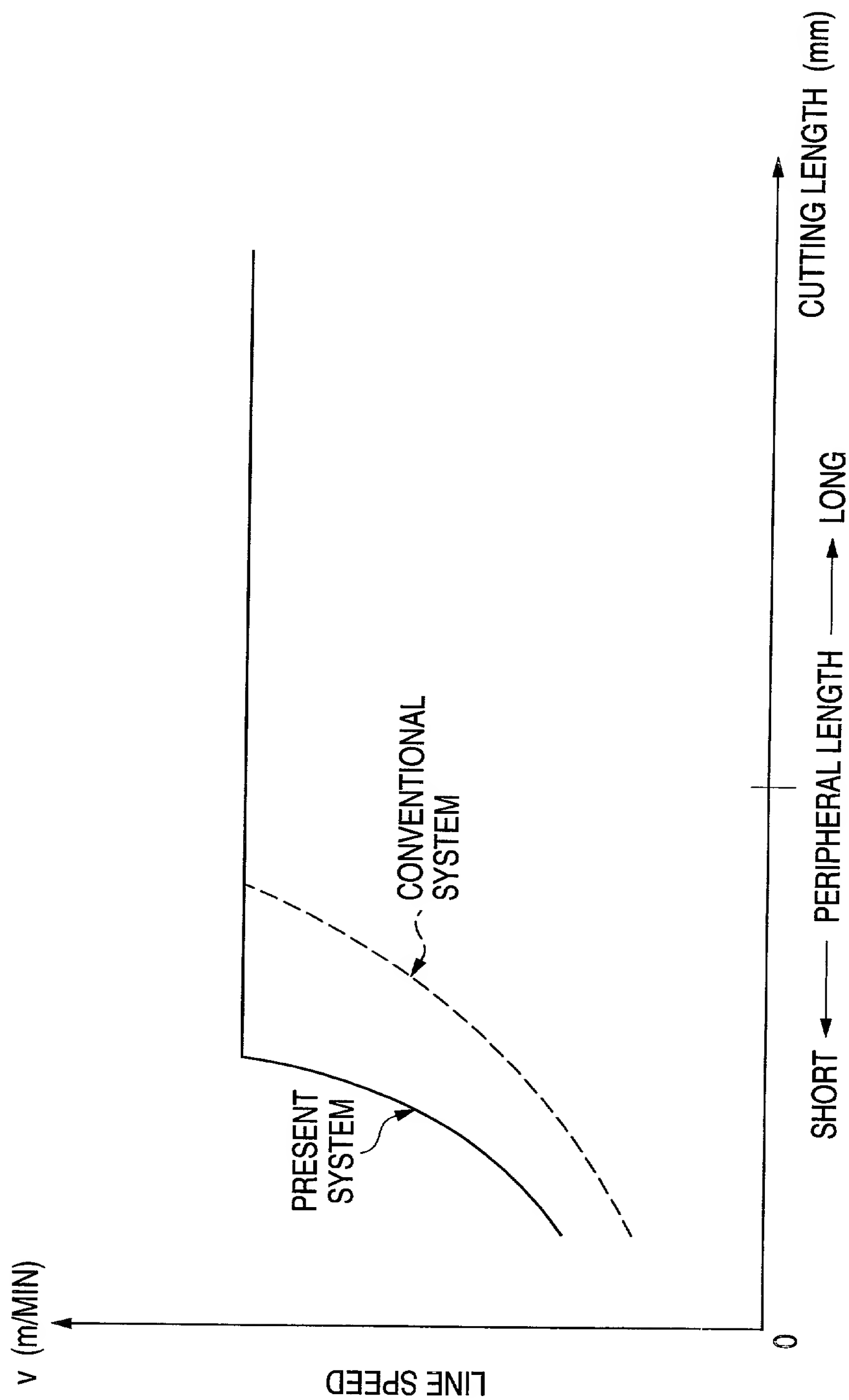

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FIG. 15

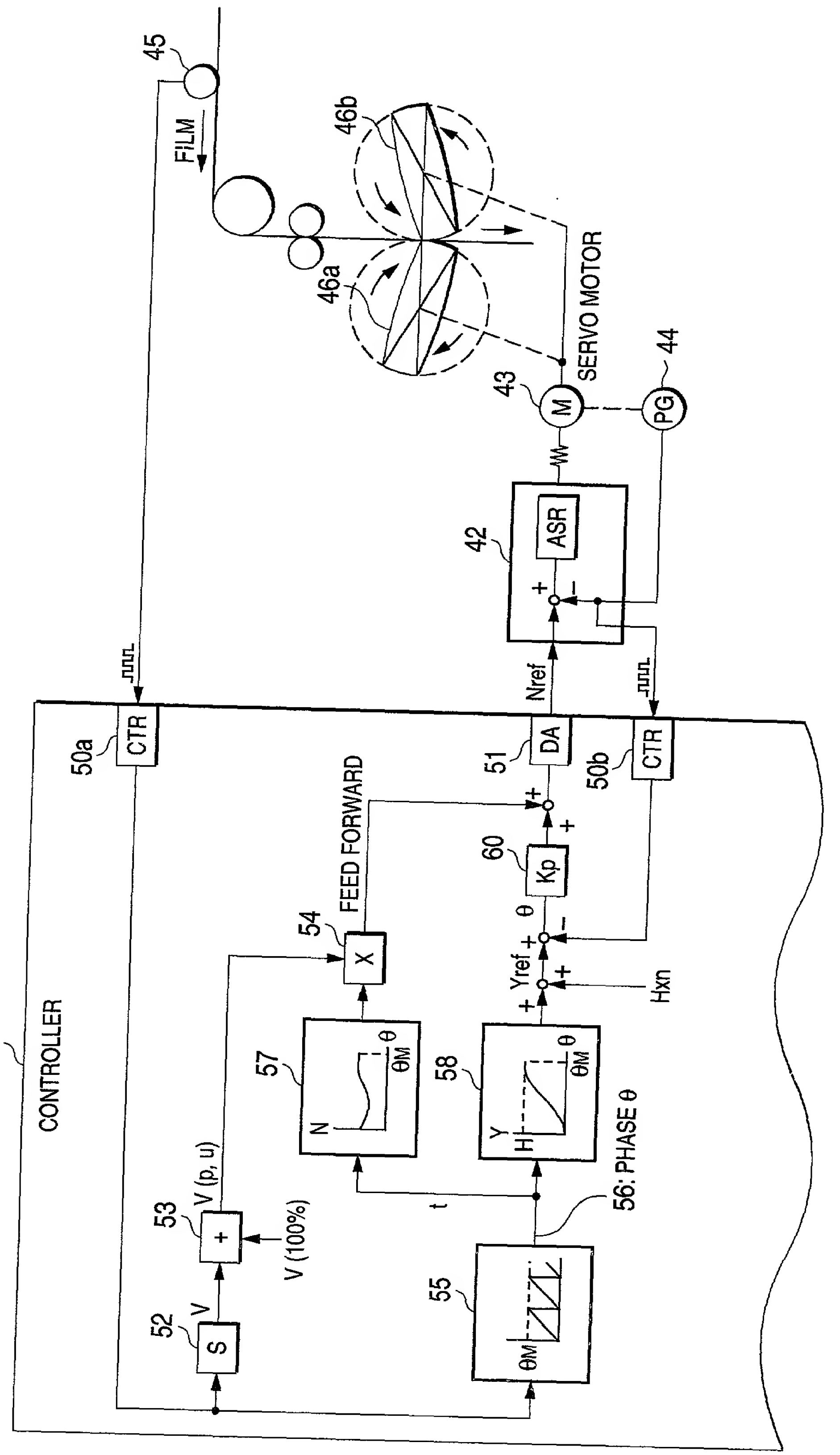

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FIG. 16A

[SINGLE HEATER LATERAL SEALING MECHANISM]

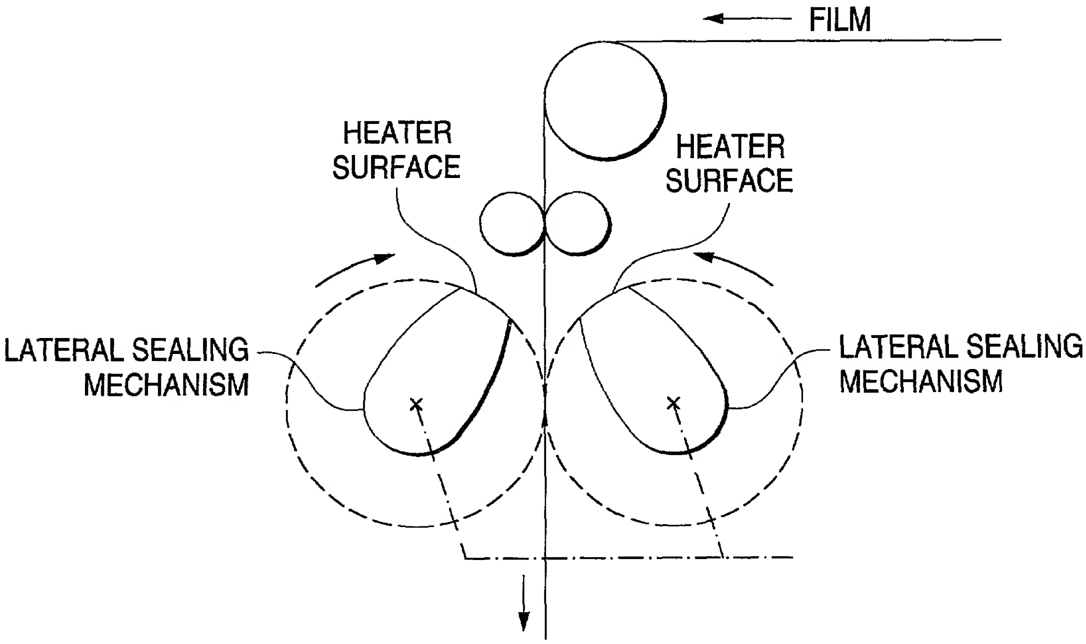
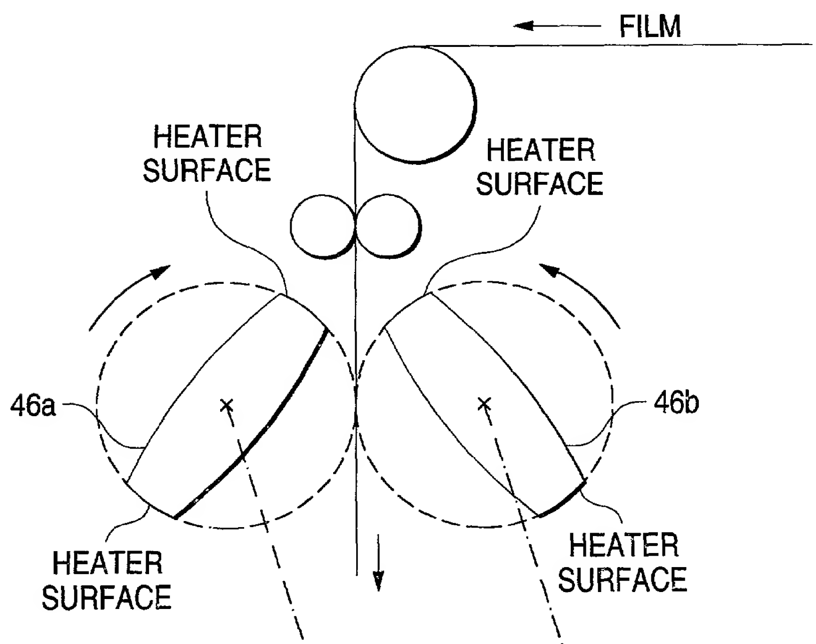


FIG. 16B

[DOUBLE HEATER LATERAL SEALING MECHANISM]



09/889047

FIG. 17

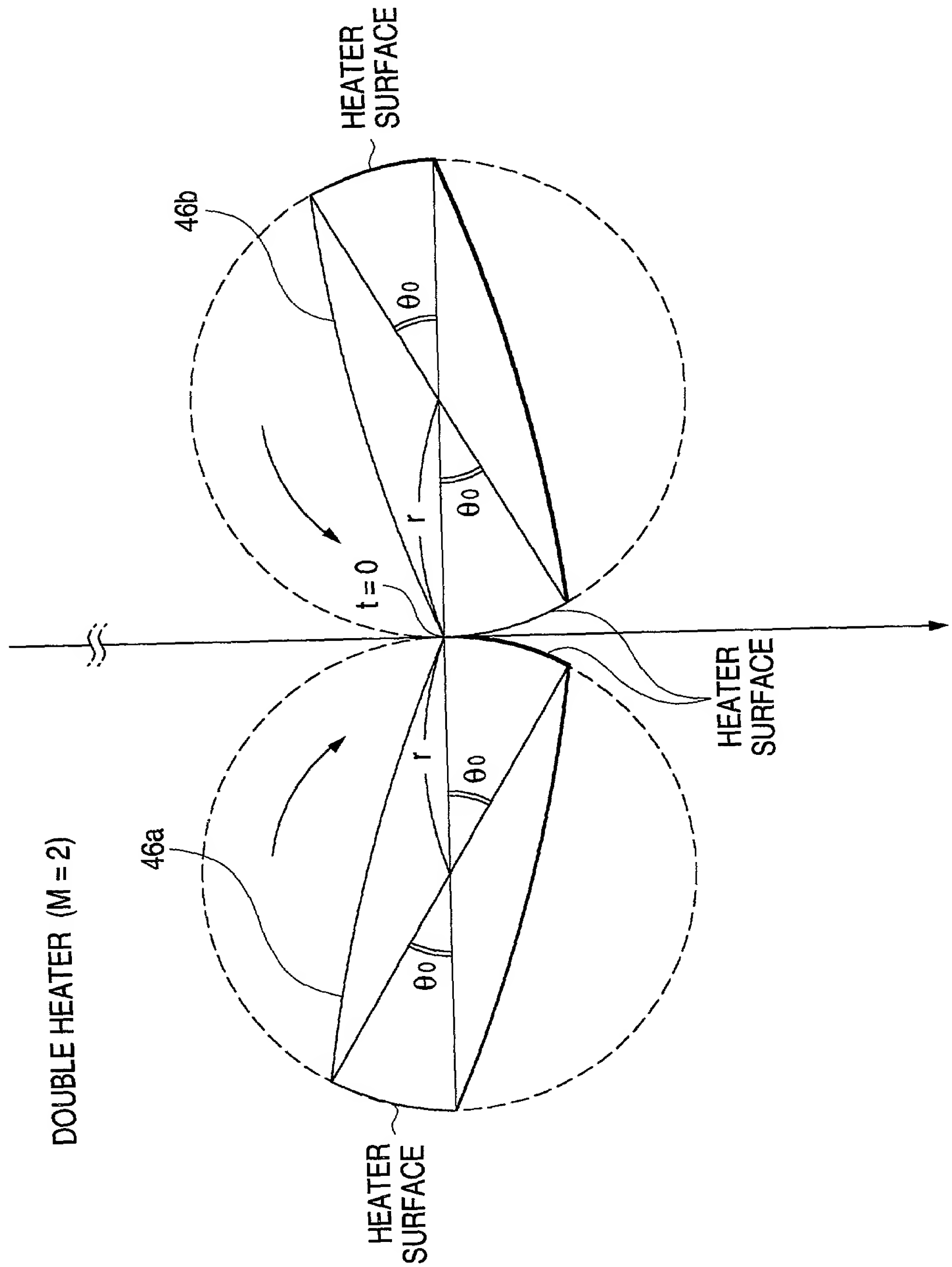


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FIG. 18A

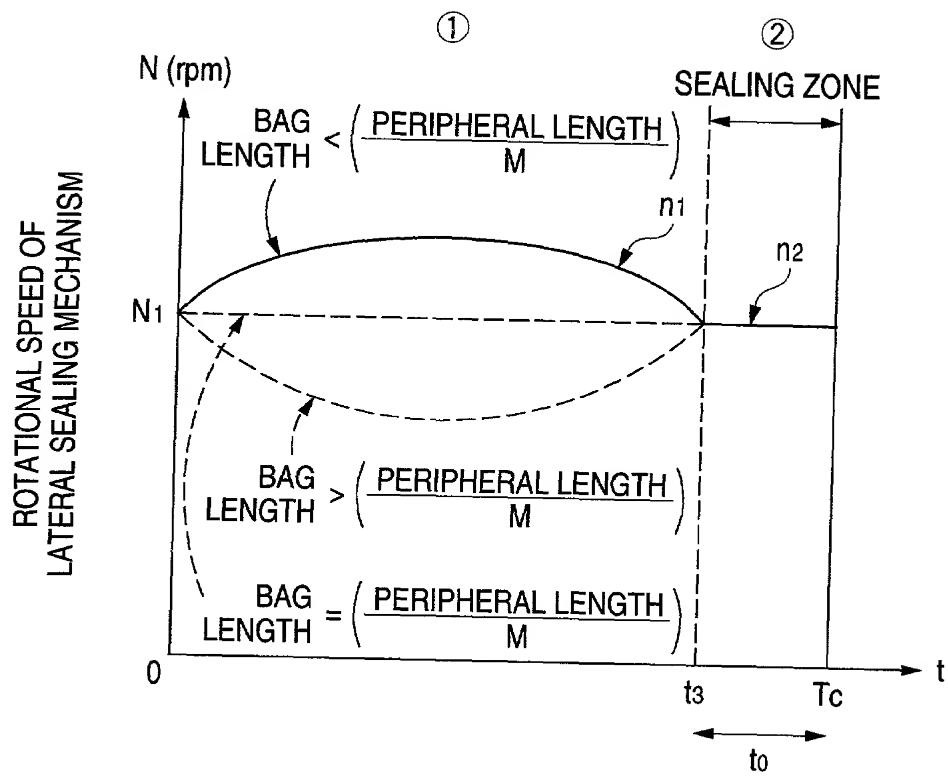

FIG. 18B

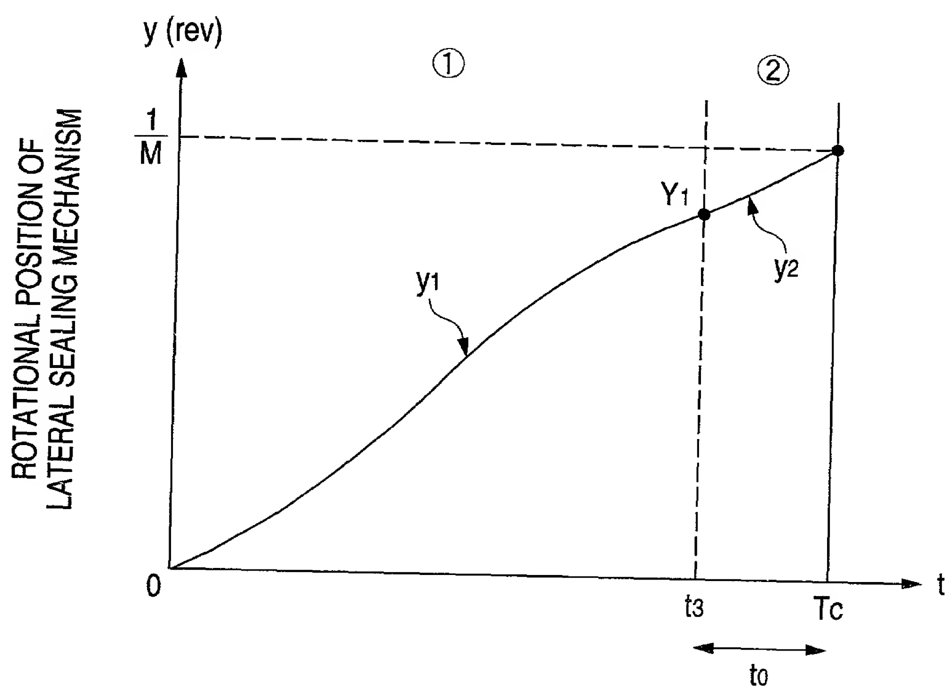

FIG. 19

ZONE	ROTATIONAL SPEED OF LATERAL SEALING MECHANISM n (rpm)	ROTATIONAL POSITION OF LATERAL SEALING MECHANISM y (rev)
① NON SEALIING ZONE	$n_1 = 60\,(3At^2 + 2Bt + C)$	$y_1 = At^3 + Bt^2 + Ct + D$
② SEALIING ZONE	$n_2 = N_1$ (CONSTANT)	$y_2 = \dfrac{\frac{1}{M} - Y_1}{Tc - t_3}\,(t - Tc) + \dfrac{1}{M}$

09/889047

FIG. 20

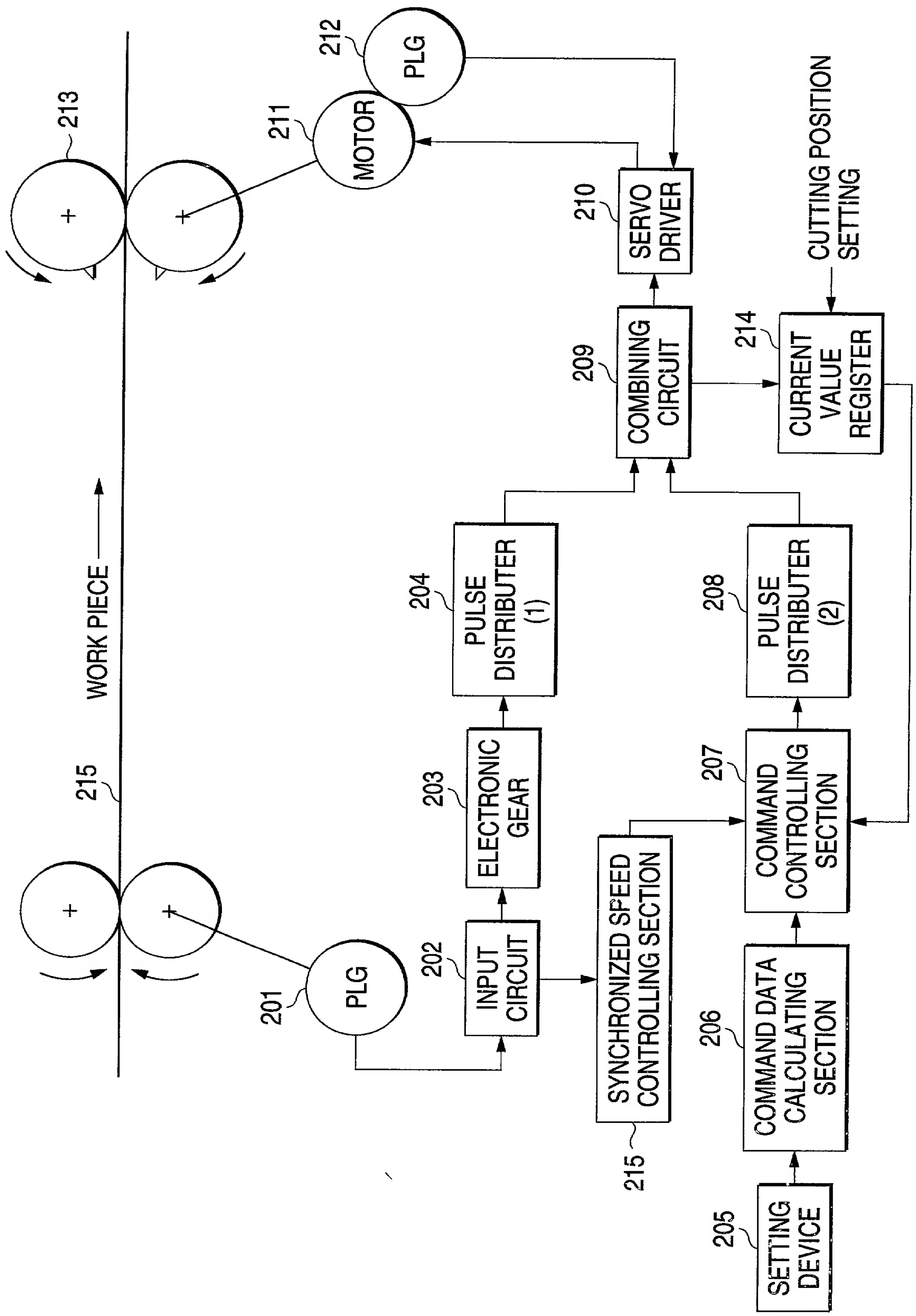

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FIG. 21A

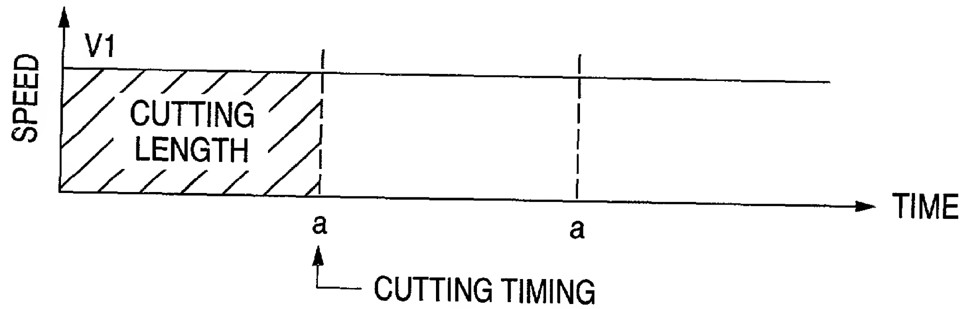

FIG. 21B

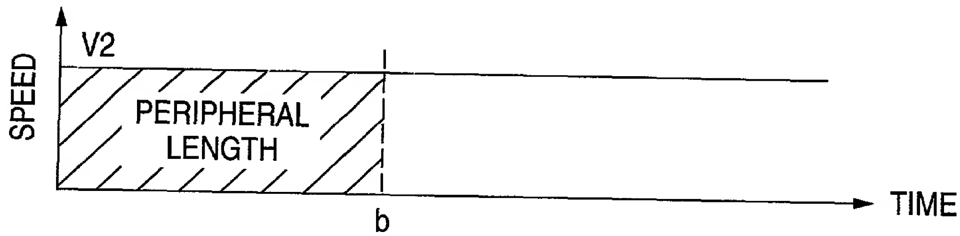

FIG. 21C

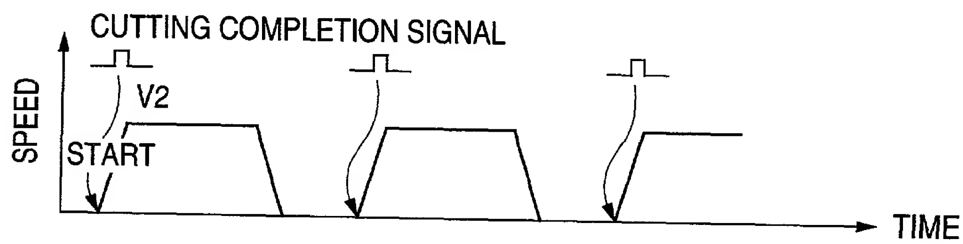

FIG. 21D

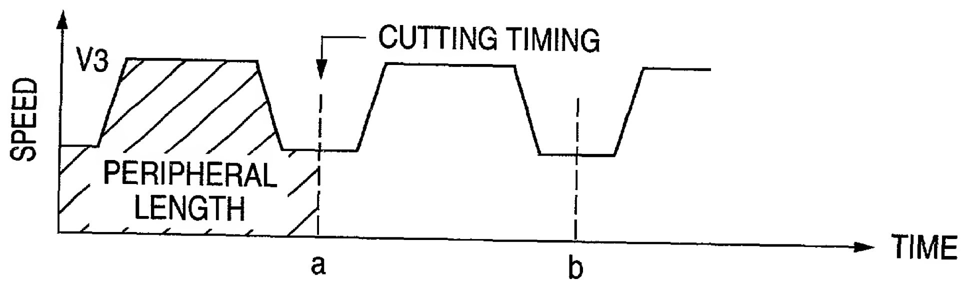

FIG. 21E

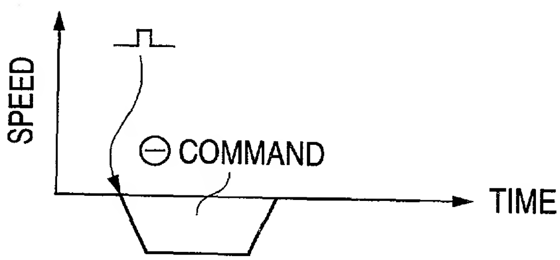

FIG. 21F

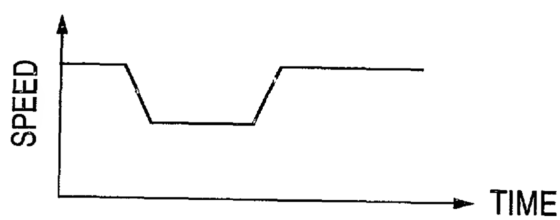

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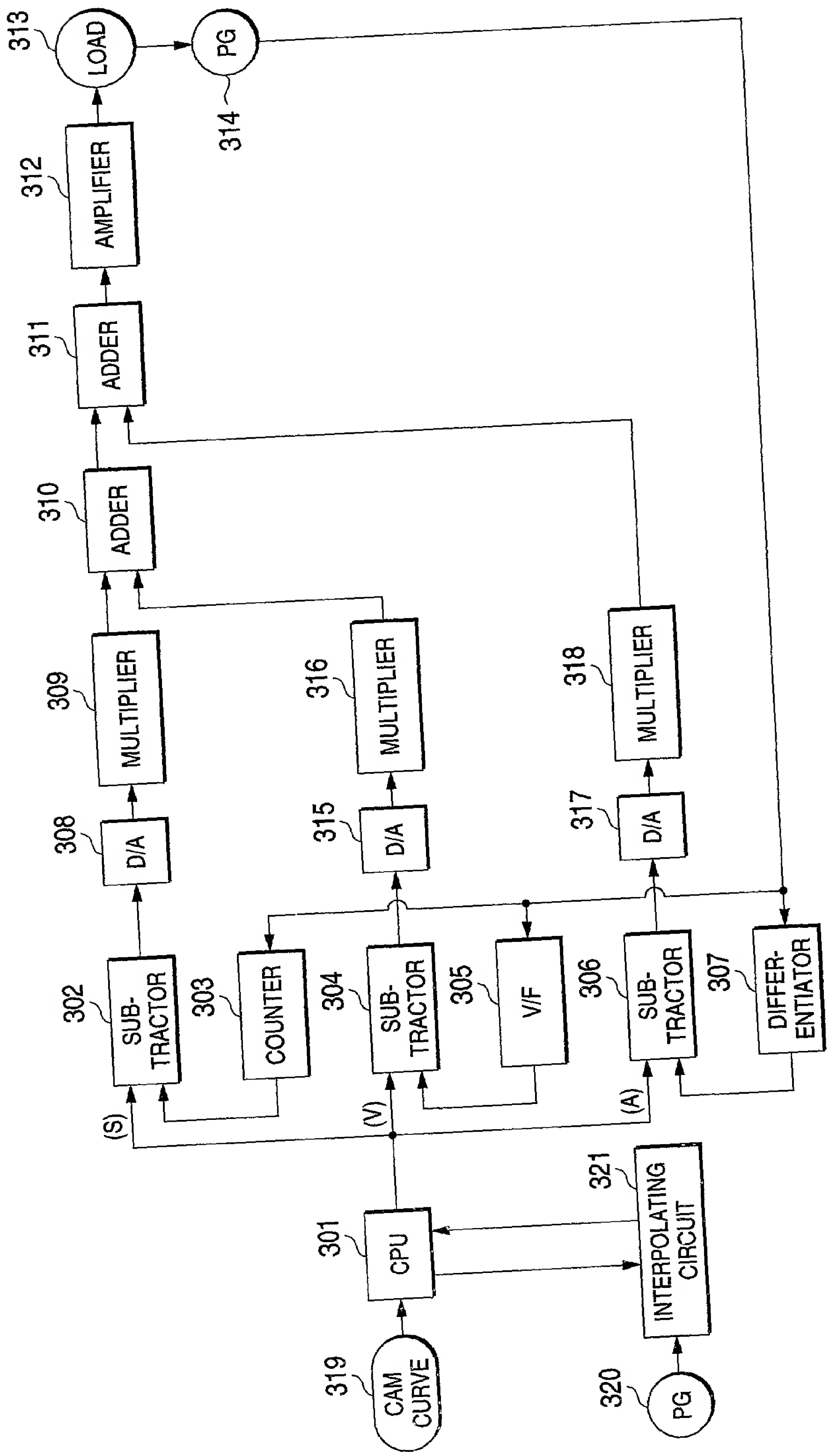
FIG. 22



09/889047

FIG. 23

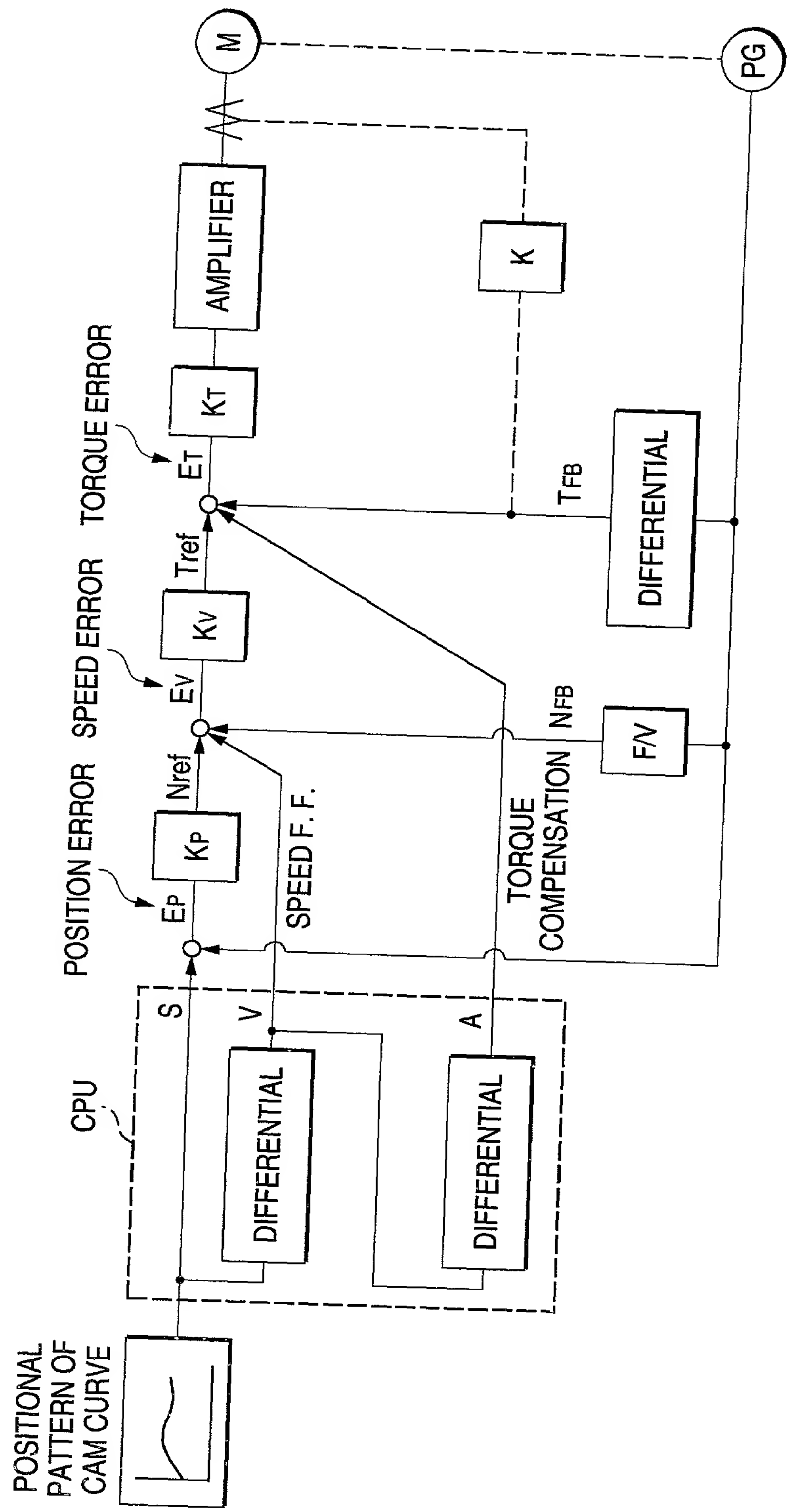


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FIG. 24A

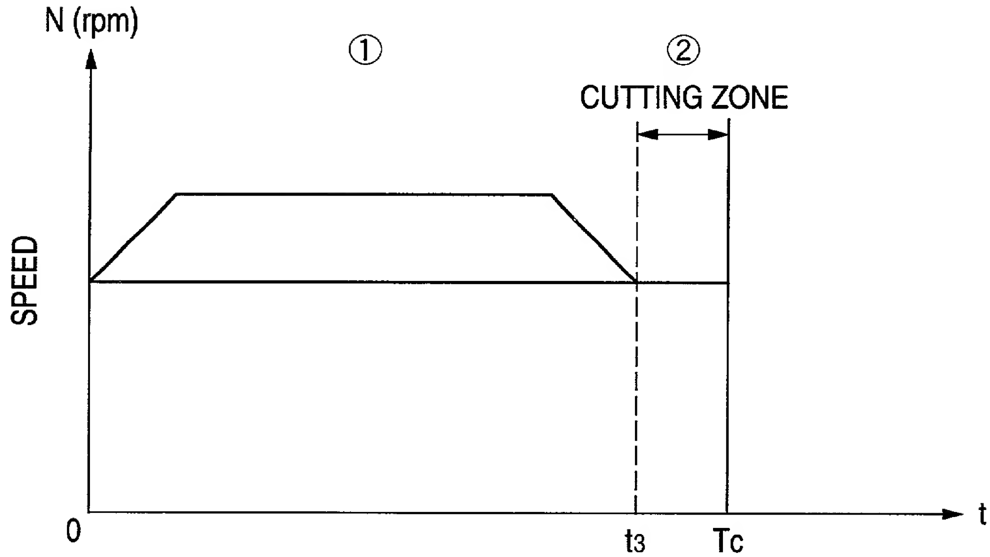
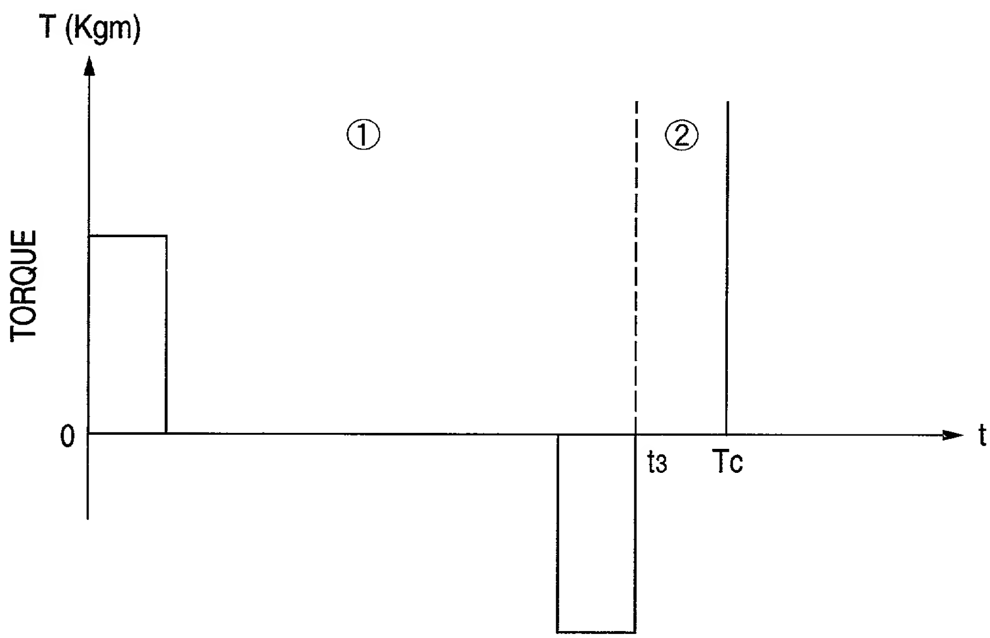


FIG. 24B



Declaration and Power of Attorney for Patent Application

特許出願宣言書及び委任状

Japanese Language Declaration

日本語宣言書

下記の氏名の発明者として、私は以下の通り宣言します。

As a below named inventor, I hereby declare that:

私の住所、私書箱、国籍は下記の私の氏名の後に記載された通りです。

My residence, post office address and citizenship are as stated next to my name,

下記の名称の発明に関して請求範囲に記載され、特許出願している発明内容について、私が最初かつ唯一の発明者(下記の氏名が一つの場合)もしくは最初かつ共同発明者であると(下記の氏名が複数の場合)信じています。

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

METHOD OF CONTROLLING AN ELECTRONIC CAM TYPE ROTARY CUTTER, AND METHOD OF PRODUCING AN ELECTRONIC CAM CURVE

上記発明の明細書(下記の欄でX印がついていない場合は、本書に添付)は、

the specification of which is attached hereto unless the following box is checked:

～ ___月___日に提出され、米国出願番号または特許協定条約国際出願番号を ____________ とし、(該当する場合) ____________ に訂正されました。

[X] was filed on January 7, 2000 as United States Application Number or PCT International Application Number PCT/JP00/00046 and was amended on November 7, 2000 (if applicable).

私は、特許請求範囲を含む上記訂正後の明細書を検討し、内容を理解していることをここに表明します。

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

私は、連邦規則法典第37編第1条56項に定義されるとおり、特許資格の有無について重要な情報を開示する義務があることを認めます。

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

Japanese Language Declaration

（日本語宣言書）

私は、米国法典第35編第119条(a)-(d)項又は第365条(b)項に基き下記の、米国以外の国の少なくとも一カ国を指定している特許協力条約第365条(a)項に基づく国際出願、又は外国での特許出願もしくは発明者証の出願についての外国優先権をここに主張するとともに、優先権を主張している本出願の前に出願された特許または発明者証の外国出願を以下に、枠内をマークすることで、示しています。

I hereby claim foreign priority under Title 35, United States Code, Section 119(a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or PCT International application having a filing date before that of the application on which priority is claimed.

Prior Foreign Applications
外国での先行出願

Priority Not Claimed
優先権主張なし

(Number) (番号)	(Country) (国名)	(Day/Month/Year Filed) (出願年月日)	Priority Not Claimed 優先権主張なし
P. Hei. 11-4523	Japan	11/January/1999	☐
			☐
			☐

私は、第35編米国法典119条(e)項に基づいて下記の米国特許出願規定に記載された権利をここに主張致します。

I hereby claim the benefit under Title 35, United States Code, Section 119(e) of any United States provisional application(s) listed below.

(Application No.)（出願番号）　(Filing Date)（出願日）

(Application No.)（出願番号）　(Filing Date)（出願日）

私は、下記の米国法典第35編第120条に基づいて下記の米国特許出願に記載された権利、又は米国を指定している特許協力条約第365条(c)に基づく権利をここに主張します。又、本出願の各請求範囲の内容が米国法典第35編第112条第1項又は特許協力条約で規定された方法で先行する米国特許出願に開示されていない限り、その先行米国出願書提出日以降で本出願書の日本国内又は特許協力条約国際出願提出日までの期間中に入手された、連邦規則法典第37編第1条第56項で定義された特許資格の有無に関する重要な情報について開示義務があることを認識しています。

I hereby claim the benefit of Title 35, United States Code Section 120 of any United States application(s), or 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of Title 35, United States Code Section 112, I acknowledge the duty to disclose any material information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of this application:

(Application No.)（出願番号）　(Filing Date)（出願日）　(Status: Patented, Pending, Abandoned)（現況：特許許可済、係属中、放棄済）

(Application No)（出願番号）　(Filing Date)（出願日）　(Status: Patented, Pending, Abandoned)（現況：特許許可済、係属中、放棄済）

私は、私自身の知識に基づいて本宣言書中で私が行う表明が真実であり、かつ私の入手した情報と私の信ずるところに基づく表明が全て真実であると信じていること、さらに故意になされた虚偽の表明及びそれと同等の行為は米国法典第18編第1001条に基づき、罰金または拘禁、もしくはその両方により処罰されること、そしてそのような故意による虚偽の声明を行えば、出願した、又は既に許可された特許の有効性が失われることを認識し、よってここに上記のごとく宣誓を致します。

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Japanese Language Declaration

（日本語宣言書）

委任状：私は、下記の発明者として、本出願に関する一切の手続きを米国特許商標局に対して遂行する弁理士又は代理人として、下記のものを指名致します。（弁護士、又は代理人の氏名及び登録番号を明記のこと）

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith (*list name and registration number)*

30—

John H. Mion, Reg. No. 18,879; Thomas J. Macpeak, Reg. No. 19,292; Robert J. Seas, Jr., Reg. No. 21,092; Darryl Mexic, Reg. No. 23,063; Robert V. Sloan, Reg. No. 22,775; Peter D. Olexy, Reg. No. 24,513; J. Frank Osha, Reg. No. 24,625; Waddell A. Biggart, Reg. No. 24,861; Louis Gubinsky, Reg. No. 24,835; Neil B. Siegel, Reg. No. 25,200; David J. Cushing, Reg. No. 28,703; John R. Inge, Reg. No. 26,916; Joseph J. Ruch, Jr., Reg. No. 26,577; Sheldon I. Landsman, Reg. No. 25,430; Richard C. Turner, Reg. No. 29,710; Howard L. Bernstein, Reg. No. 25,665; Alan J. Kasper, Reg. No. 25,426; Kenneth J. Burchfiel, Reg. No. 31,333; Gordon Kit, Reg. No. 30,764; Susan J. Mack, Reg. No. 30,951; Frank L. Bernstein, Reg. No. 31,484; Mark Boland, Reg. No. 32,197; William H. Mandir, Reg. No. 32,156; Scott M. Daniels, Reg. No. 32,562; Brian W. Hannon, Reg. No. 32,778; Abraham J. Rosner, Reg. No. 33,276; Bruce E. Kramer, Reg. No. 33,725; Paul F. Neils, Reg. No. 33,102, Brett S. Sylvester, Reg. No. 32,765; Robert M. Masters, Reg. No. 35,603 and George F. Lehnigk, Reg. No. 36,359.

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2100 Pennsylvania Avenue, N.W., Washington, D.C. 20037-3202

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(202)293-7060

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国籍	Citizenship Japan
郵便の宛先	Post office address c/o KABUSHIKI KAISHA YASKAWA DENKI,
	2-1, Kurosaki-Shiroishi, Yahatanishi-ku, Kitakyushu-shi, Fukuoka 806-0004 JAPAN
第二共同発明者名（該当する場合）	Full name of second joint inventor, if any
第二発明者の署名 日付	Second inventor's signature Date
住所	Residence
国籍	Citizenship
郵便の宛先	Post office address

（第三以降の共同発明者についても同様に記載し、署名をすること。）(Supply similar information and signature for third and subsequent joint inventors.)